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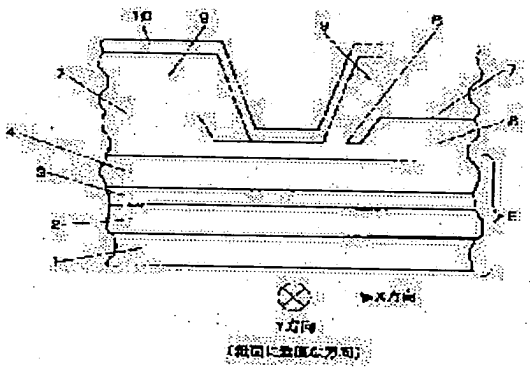
(54) THIN-FILM MAGNETIC HEAD AND METHOD OF MANUFACTURE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a thin-film magnetic head having high sensitivity and stable reproducing performance, by supplying stable longitudinal bias and to provide a method for manufacturing the thin-film magnetic head, in a reproducing head having a narrower gap length for the purpose of reproducing a recorded signal of a short wavelength accompanying making of higher recording density.
SOLUTION: A connection magnetic field at a part connected with a part having a large film thickness of a bias antiferromagnetic film of a free magnetic layer can be strengthened and a connection magnetic field at a part connected with a part having thin-film thickness of the bias antiferromagnetic film of the free magnetic layer can be weakened by forming the bias antiferromagnetic film having a stepped part by the difference of film thickness on the free magnetic layer formed at the highest part of the magneto resistive element. Thereby, Barkhausen noise can be stably suppressed regardless of the gap length and reproducing sensitivity can be enhanced.



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* NOTICES *

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1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The magnetoresistance-effect type thin film magnetic head which consists of a vertical bias layer which has a magnetoresistance-effect element through an insulating material, and was prepared in contact with the aforementioned magnetoresistance-effect element between the lower shield layers and up shield layers which are characterized by providing the following, and an electrode lead layer for passing the signal current. The magnetoresistance-effect element which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer. The bias antiferromagnetism film which has the 1st flat surface with the level difference by the thickness difference, and the 2nd flat surface.

[Claim 2] The joint magnetic field by antiferromagnetism combination of the portion of the aforementioned free magnetic layer which is in contact with the portion of the aforementioned bias antiferromagnetism film which constitutes the 1st small flat surface of the above of thickness is 8 kA/m. Following (below 100e) The thin film magnetic head according to claim 1 which comes out and is characterized by a certain thing.

[Claim 3] The manufacture method of the thin film magnetic head characterized by providing the following. The 1st process which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer one by one, and forms a magnetoresistance-effect element on a lower gap insulating layer. After forming a bias antiferromagnetism layer membrane so that the aforementioned magnetoresistance-effect element top may be covered, The 2nd process which forms a bias antiferromagnetism film with the level difference which consists of a portion with the small thickness which deletes a part of aforementioned bias antiferromagnetism layer membrane, and has the 1st flat surface, and a large portion of the thickness which has the 2nd flat surface, The 3rd process which deletes a part of electrode lead layer membrane at least, and forms the electrode lead layer of a right-and-left couple so that the aforementioned bias antiferromagnetism film top may be covered, an electrode lead layer membrane may be formed and a part of 1st flat surface [at least] of the aforementioned bias antiferromagnetism film may be exposed.

[Claim 4] the 3rd process of a claim 3 — setting — a 1st [of the aforementioned bias antiferromagnetism film] flat-surface top — a mushroom — the manufacture method of the thin film magnetic head according to claim 3 characterized by having the 3rd process which forms a type resist and forms the electrode lead layer of a right-and-left couple on the aforementioned bias antiferromagnetism film

[Claim 5] The 2nd process of a claim 3 and the 3rd process which are characterized by providing the following. The 2nd process which forms a bias antiferromagnetism layer membrane so that the aforementioned free magnetic layer top may be covered. Furthermore, so that a part of aforementioned bias antiferromagnetism layer membrane may be shaved off and it may expose, after forming an electrode lead layer membrane so that a it top may be covered A part of afor mentioned electrode lead layer membrane and each aforementioned bias antiferromagnetism layer membrane are deleted. The upper surface of the aforementioned bias antiferromagnetism layer membrane which it was deleted and was exposed The 1st flat surface, The 3rd process which forms the electrode lead layer of a right-and-left couple on the 2nd [of the bias antiferromagnetism film which has a level difference by the thickness difference which makes the upper surface of the aforementioned bias antiferromagnetism layer membrane at the time of membrane formation the 2nd flat surface, and the aforementioned bias antiferromagnetism film] flat surface.

[Claim 6] The manufacture method of the thin film magnetic head characterized by providing the following. The 1st proc ss which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer one by one, and forms a magnetoresistance-effect element on a low r gap insulating layer. So that the aforementioned free magnetic layer top which constitutes the aforementioned magn toresistance-effect element may be covered A type resist is formed. the 1st bias antiferromagnetism film — forming membranes — the upper surface of the bias antiferromagnetism film of the above 1st — a mushroom — The upper surface which carried out membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple, and has exposed the bias antiferromagnetism film of the above 1st The 1st flat surface, The upper surface of the bias antiferromagnetism film of the above 2nd is made into the 2nd flat surface, and the thickness of the portion of the 1st flat surface of the above is the thickness of the bias antiferromagnetism film of the above 1st. The 2nd process which forms the bias antiferromagnetism film which whose thickness of the portion of the 2nd flat surface of the above is the sum of the thickness of the bias antiferromagnetism film of the above 1st, and the thickness of th bias antiferromagnetism film of the above 2nd, and has the level difference which has a thickness difference among them, The 3rd process which carries out membrane formation formation of the electrode lead layer of a right-and-left couple on the bias antiferromagnetism film of the above 2nd.

[Claim 7] So that the aforementioned free magnetic layer top which constitutes the aforementioned magn toresistance-effect element may be cover d in th 2nd proc ss of a claim 6 A type resist is form d. th 1st bias antiferromagn tism film — forming membranes — the upper surfac of the bias antiferromagnetism film of th above 1st — a mushroom — After cleaning the upp r surfac of the bias antiferromagnetism film of the above 1st, membrane formation formation of the 2nd bias antif rromagnetism film of a right-and-left couple is carri d out. The 1st flat surface and th upper surface of the bias antiferr magnetism film of th above 2nd ar mad into the 2nd flat surfac for th upp r surfac which has expos d the bias antif rromagnetism film of th above 1st. Th manufactur method of the thin film magnetic head according to claim 6 characterized by having the 2nd proc ss which forms a bias antiferromagn tism film with the level differ nce by the thickness difference between the 1st flat surfac of the above, and th 2nd flat surfac f the above.

[Claim 8] S that the bias antiferromagnetism film top of the abov 2nd of the portion which the bias

antiferromagnetism film of the above 1st exposed, and a right-and-left couple may be covered. after deleting the resist formed at the 2nd process of the above in the 3rd process of a claim 6 So that an electrode lead layer membrane may be formed and some bias antiferromagnetism films [at least] of the above 1st may be exposed The manufacture method of the thin film magnetic head given in either the claim 6 characterized by deleting a part of aforementioned electrode lead layer membrane at least, and having the 3rd process which forms the electrode lead layer of a right-and-left couple, or the claim 7.

[Claim 9] the 1st flat-surface top of the bias antif rromagnetism film of the above 1st after deleting the resist formed at the 2nd proc ss of the above in the 3rd process of a claim 6 -- a mushroom -- the manufacture method of the thin film magnetic head given in either the claim 6 characterized by having the 3rd process which forms a type resist and forms the electrode lead layer of a right-and-left couple, or the claim 7

[Claim 10] The manufacture method of the thin film magnetic head according to claim 3 to 9 characterized by having the 4th process which forms a cap layer so that the portion top which the 1st flat surface of the aforementioned electrode lead layer of the right-and-left couple formed on the aforementioned bias antiferromagnetism film which has a level difference, and the aforementioned bias antiferromagnetism film exposed may be covered.

[Claim 11] The manufacture method of the thin film magnetic head characterized by providing the following. The 1st process which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer one by one, and forms a magnetoresistance-effect element on a lower gap insulating layer. A type resist is formed. the aforementioned free magnetic layer top -- a wrap -- like -- the 1st bias antiferromagnetism film -- forming membranes -- further -- a it top -- a wrap -- the cap layer top aforementioned after forming a cap layer like -- a mushroom -- Shave off a part of aforementioned cap layer at least, and membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple is carried out on it so that the bias antiferromagnetism film of the above 1st may be exposed. The upper surface of the bias antiferromagnetism film of the above 1st which touched the aforementioned cap layer The 1st flat surface, The upper surface of the bias antiferromagnetism film of the above 2nd is made into the 2nd flat surface, and the thickness of the portion of the 1st flat surface of the above is the thickness of the bias antiferromagnetism film of the above 1st. The 2nd process which forms the bias antiferromagnetism film which whose thickness of the portion of the 2nd flat surface of the above is the sum of the thickness of the bias antiferromagnetism film of the above 1st, and the thickness of the bias antiferromagnetism film of the above 2nd, and has the level difference which has a thickness difference among them, The 3rd process which carries out membrane formation formation of the electrode lead layer of a right-and-left couple on the bias antiferromagnetism film of the above 2nd.

[Claim 12] the cap layer top aforementioned after deleting the resist formed at the 2nd process of the above in the 3rd process of a claim 11 -- a mushroom -- the manufacture method of the thin film magnetic head according to claim 11 characterized by forming a type resist and having the 3rd process which carries out membrane formation formation of the electrode lead layer of a right-and-left couple

[Claim 13] After deleting the resist formed at the 2nd process of the above in the 3rd process of a claim 11, so that the aforementioned bias antiferromagnetism film [of the above 2nd] and cap layer top may be covered So that an electrode lead layer membrane may be formed and a part of aforementioned cap layer [at least] may be exposed The manufacture method of the thin film magnetic head given in either the claim 11 characterized by deleting a part of aforementioned electrode lead layer membrane at least, and having the 3rd process which forms the electrode lead layer of a right-and-left couple, or the claim 12.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention is applied to the equipment which performs high-density record and reproduction to magnetic-recording media, such as a magnetic disk unit (HDD equipment), gives the bias magnetic field especially stabilized in the free magnetic layer of a magnetoresistance-effect element, and relates to the high magnetoresistance-effect type thin film magnetic head and its manufacture method of a regeneration efficiency.
[0002]
[Description of the Prior Art] In recent years, in the record and reproduction to magnetic-recording media, such as a magnetic disk unit (HDD equipment), improvement in processing speed and the need for large-capacity-izing of storage capacity are increasing, and the measure for a raise in recording density is being strengthened.
[0003] Hereafter, the conventional thin film magnetic head is explained using a drawing.
[0004] Drawing 21 and drawing 22 are drawings showing the conventional thin film magnetic head, drawing 21 is a tropia schematic diagram and drawing 22 is the transverse-plane outline diagram of the thin film magnetic head.
[0005] For example, the thin film magnetic head used for the record reproduction to the magnetic-recording medium of the signal in a magnetic disk unit has many which are called so-called MR (GMR) inductive combined head as shown in drawing 21 .
[0006] In drawing 21 , the nonmagnetic insulating material of aluminum2O3, AlN, or SiO2 grade is used on the lower shield layer 211 formed by soft magnetic materials, such as a permalloy, Co system amorphous magnetic film, or Fe system alloy magnetic film, the lower gap insulating layer 212 is formed, and it is a magnetoresistance-effect element (MR element or GMR element.) to the upper surface further. Laminating membrane formation formation of the 213 called GMR element is carried out hereafter, and the vertical bias layer 214 is formed by the right-and-left both-sides edge of the GMR element 213 with material, such as a CoPt alloy. Furthermore, the ridgeline which is a nodal line of the upper surface and the both-sides side of the GMR element 213 to make is touched, material, such as Cu, Cr, or Ta, is used for the upper surface of the vertical bias layer 214, and the electrode lead layer 215 of a right-and-left couple is formed. Here, as the upper surface of the vertical bias layer 214 and the upper surface of a part of GMR element 213 are started, you may form the electrode lead layer 205. Next, the up gap insulating layer 216 is formed on the portion which the electrode lead layer 215 and the GMR element 213 exposed using the same nonmagnetic insulating material as the lower gap insulating layer 212. Furthermore, on the up gap insulating layer 216, membrane formation formation of the up shield layer 217 is carried out using the same soft magnetic materials as the lower shield layer 211, and the magnetoresistance-effect type thin film magnetic-head section 218 for reproduction is constituted.
[0007] Next, the record gap layer 221 is formed using the same nonmagnetic insulating material as the lower gap insulating layer 212 on the upper surface of the up shield layer 217. Furthermore, the up shield layer 217 is countered through the record gap layer 221. And membrane formation formation of the up magnetic pole 222 which is in contact with the up shield layer 217 is carried out using soft magnetic materials in other portions. Between the up shield layer 217, the portion which the up magnetic pole 222 has countered, and the portion to which the up magnetic pole 222 is in contact with the up shield layer 217, through the record gap layer 221 The coil coil 223 insulated from the up shield layer 217 and the up magnetic pole 222 through the insulating material (not shown) is formed, and the induction-type thin film magnetic-head section 220 for record is constituted. Here, the up shield layer 217 has the function which combines the shield function of the magnetoresistance-effect type thin film magnetic-head section 218 for r production, and the lower magnetic pole function of the induction-type thin film magnetic-head section 220 for record.
[0008] By supplying record current to the coil coil 223, a record magnetic field occurs in the up magnetic pole 222 and the up shield layer 217 of the induction-type thin film magnetic-head section 220 for record, magnetic leakage flux occurs between the up magnetic poles 222 and the up shield layers 217 which counter through the record gap layer 221, and a record signal is recorded on a magnetic-recording medium. Moreover, the magnetic field of the signal recorded on the magnetic-recording medium by which the signal was recorded is reproduced in the magn toresistance-effect type thin film magnetic-head section 218 for reproduction, and the regenerative signal according to the resistance change by the GMR element 213 is detected from the terminal of the electrode lead layer 215.
[0009] As the transverse-plane outline diagram near [in the reproducing-head section of the thin film magnetic head] the magnetoresistance-effect element is shown in drawing 22 On the lower gap insulating layer 212 formed by the upp r surface of the lower shield layer 211 The antiferromagnetism layer 224, FeNi system alloy film which are material, such as a FeMn system alloy film and a PtMn system alloy film Laminating membrane formation of the cap layer 228 mad from the non-magn tic layer 226 made fr m the fixed magnetic layer 225 made from a permalloy, Co, a FeCo alloy film, etc., Cu, etc., the fixed magnetic layer 225 and the free magnetic layer 227 made into the same mat rial, Ta, etc. is carried out one by one. It is shav d off so that it may hav the field where the right-and-left both-sides edge inclin d at etching processes, such as ion milling, and the GMR element 213 is formed. The right-and-left both-sides end face of the GMR element 213 is touched, the vertical bias layer 214 of a right-and-left couple is form d, and the el ctr de lead layer 215 of a right-and-l ft couple is formed n it. Furthermor , on them, the up gap insulating layer 216 is form d, th up shield layer 217 is furth r formed on it, and the magn toresistance- ffect type thin film head for repr duction is constituted. In order to r produce the record signal of th short wavelength corresponding to a raise in recording d nsity in r cent years, the reproduction h ad gap length 229 is b coming still smaller.
[0010]

[Problem(s) to be Solved by the Invention] However, in the reproducing-head section of the thin film magnetic head of the above-mentioned conventional composition, in order to reproduce the signal recorded on the magnetic-recording medium by short wavelength, it is necessary to make reproduction head gap length small. Reproduction head gap length The distance, i.e., the lower gap insulating layer, from the upper surface of a lower shield layer to the inferior surface of tongue of an up shield layer, Are the sum of each thickness of a GMR element and an up gap insulating layer, and the vertical bias layer of the right-and-left couple which making this distance small has in the both sides of a GMR element will approach a lower shield layer or an up shield layer. Although the magnetic field of a vertical bias layer becomes easy to escape in a lower shield layer or an up shield layer and a bias magnetic field starts the free magnetic layer near the vertical bias layer of a GMR element In order for a bias magnetic field to become weaker in a part for the center section of a free magnetic layer (a part for the center section of the direction of the width of recording track), and for the direction of magnetization of a free magnetic layer to become unstable, and not to obtain the regenerative signal which the noise increased and was stabilized but to obtain the stable regenerative signal Although magnetization of a free magnetic layer was stabilized and the Barkhausen noise was suppressed when the cure which strengthens a vertical bias magnetic field was performed, sensitivity fell, and the direction of magnetization of a fixed magnetic layer also inclined greatly, and had the technical problem that symmetric property got worse.

[0011] this invention solves the above-mentioned technical problem, adds the vertical bias stabilized in the free magnetic layer by the joint magnetic field combined with the antiferromagnetism film which has the level difference from which the thickness formed on the free magnetic layer of a GMR element differs in antiferromagnetism, stabilizes the direction of magnetization of a free magnetic layer, suppresses generating of a Barkhausen noise, and aims at offering the good magnetoresistance-effect type thin film magnetic head and its manufacture method of reproducibility ability.

[0012]

[Means for Solving the Problem] In order to attain this purpose, the thin film magnetic head of this invention has the composition it was made to consist of a magnetoresistance-effect element which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, and a bias antiferromagnetism film which has the 1st flat surface with the level difference by the thickness difference, and the 2nd flat surface. moreover, joint magnetic field by antiferromagnetism combination of the portion of the free magnetic layer which is in contact with the portion of the bias antiferromagnetism film with which the thin film magnetic head of this invention constitutes the 1st flat surface with small thickness 8 or less (below 100e) kA/m it is — having made — it has composition

[0013] By this composition, a bias magnetic field strong against a portion (portions other than the width-of-recording-track portion of a free magnetic layer) to fix the magnetization direction to very strongly is applied. On the other hand, although a bias magnetic field must be applied in order to suppress a Barkhausen noise It becomes possible [controlling by thickness of the antiferromagnetism film of each portion easily] to apply the optimal bias magnetic field for a portion (width-of-recording-track portion of a free magnetic layer) not to apply a not much strong magnetic field, since reproduction sensitivity will fall if a strong magnetic field is applied. that is, to the free magnetic layer which is in contact with the antiferromagnetism film of the portion of the 2nd big flat surface of thickness The joint magnetic field by strong antiferromagnetism combination is acquired, and the direction of the magnetization becomes what was stabilized very much. The sake, Even if the joint magnetic field by antiferromagnetism combination of the portion of the free magnetic layer which is in contact with the antiferromagnetism film of the portion of the 1st small flat surface of thickness is small Become easy to be suitable in the direction of magnetization of the free magnetic layer which was stabilized and is in contact with the antiferromagnetism film of the portion of the 2nd big flat surface of thickness, and the direction of the same magnetization. Moreover, since the antiferromagnetism joint magnetic field of the portion of the free magnetic layer which is in contact with the antiferromagnetism film of the portion of the 1st small flat surface of thickness is small, By the external magnetic field, i.e., the magnetic field from a magnetic-recording medium, the direction of the magnetization becomes easy to change, there can be little generating of a Barkhausen noise, reproduction sensitivity can be high, and reproducibility ability can be stabilized. moreover, since there is no influence which is not concerned with gap length, but has the same effect, and this bias magnetic field has on a fixed magnetic layer in order to apply a bias magnetic field by the joint magnetic field with an antiferromagnetism film and the inclination of magnetization of the fixed magnetic layer by it is not produced, either, degradation of the symmetric property of an output wave is suppressed Moreover, by choosing the thickness of the antiferromagnetism film of the portion of the first flat surface the optimal, the joint magnetic field of an antiferromagnetism film and a free magnetic layer can be stabilized and given to the strength of 8 or less kA/m, and improvement in reproducibility ability can be aimed at.

[0014] Moreover, the manufacture method of the thin film magnetic head of this invention So that the 1st process which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer one by one, and forms a magnetoresistance-effect element on a lower gap insulating layer, and a magnetoresistance-effect element top may be covered The 2nd process which forms a bias antiferromagnetism film with the level difference which consists of a portion with the small thickness which deletes a part of bias antiferromagnetism layer membrane, and has the 1st flat surface after forming a bias antiferromagnetism layer membrane, and a large portion of the thickness which has the 2nd flat surface, A part of electrode lead layer membrane is deleted at least, and it has the 3rd process which forms the electrode lead layer of a right-and-left couple so that a bias antiferromagnetism film top may be covered, an electrode lead layer membrane may be formed and a part of 1st flat surface [at least] of a bias antiferromagnetism film may be exposed. moreover, the manufacture method of th thin film magnetic head of this invention — a 1st [of a bias antiferromagnetism film] flat-surfac top — a mushroom — it has the 3rd process which forms a type resist and forms th electrode lead layer of a right-and-left couple on a bias antiferromagnetism film Mor ov r, the manufacture method of th thin film magnetic head of this invention Further with the 2nd process which forms a bias antiferromagnetism layer membran so that a it top may be cov red so that a free magnetic layer top may b covered So that a part of bias antiferromagnetism layer membran may be shaved off and it may expose, after forming an electrode lead lay r membran A part of el ctr de lead layer membrane and ach bias antiferromagnetism layer membran ar deleted. The upper surface of the bias antiferromagnetism layer membrane which it was deleted and was exposed Th 1st flat surface, It has the 3rd process which forms the electrode lead lay r of a right-and-left couple on the 2nd [of the bias antif rromagn tism film which has a level diff rence by the thickness differ nce which makes the upper surface of the bias antiferromagnetism lay r membrane at the time of membrane formation the 2nd flat surface, and a bias antiferromagn tism film] flat surface.

Moreover, the manufacture method of the thin film magnetic head of this invention So that the 1st process [which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer one by one, and forms a magnetoresistance-effect element on a lower gap insulating layer], and free magnetic layer top which constitutes a magnetoresistance-effect element may be covered A type resist is formed. the 1st bias antiferromagnetism film -- forming membranes -- the upper surface of the 1st bias antif rromagnetism film -- a mushroom -- The upper surface which carried out membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple, and has exposed the 1st bias antiferromagnetism film The 1st flat surface, The upper surface of the 2nd bias antif rromagnetism film is made into the 2nd flat surface, and the thickness of the portion of the 1st flat surface is the thickness of the 1st bias antiferromagnetism film. The 2nd process which forms the bias antiferromagnetism film which whose thickness of the portion of the 2nd flat surface is the sum of the thickness of the 1st bias antiferromagnetism film, and the thickness of the 2nd bias antiferromagnetism film, and has the level difference which has a thickness difference among them, On the 2nd bias antiferromagnetism film, it has the 3rd process which carries out membrane formation formation of the electrode lead layer of a right-and-left couple. Moreover, the manufacture method of the thin film magnetic head of this invention A type resist is formed. the aforementioned free magnetic layer top which constitutes a magnetoresistance-effect element -- a wrap -- like -- the 1st bias antiferromagnetism film -- forming membranes -- the upper surface of the 1st bias antiferromagnetism film -- a mushroom -- After cleaning the upper surface of the 1st bias antiferromagnetism film, membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple is carried out. The 1st flat surface and the upper surface of the 2nd bias antiferromagnetism film are made into the 2nd flat surface for the upp r surface which has exposed the 1st bias antiferromagnetism film, and it has the 2nd process which forms a bias antiferromagnetism film with the level difference by the thickness difference between the 1st flat surface and the 2nd flat surface. Moreover, the manufacture method of the thin film magnetic head of this invention So that the 2nd bias antiferromagnetism film top of the portion which the 1st bias antiferromagnetism film exposed, and a right-and-left couple may be covered, after deleting the resist formed at the 2nd process of the above A part of electrode lead layer membrane is deleted at least, and it has the 3rd process which forms the electrode lead layer of a right-and-left couple so that an electrode lead layer membrane may be formed and a part of 1st bias antiferromagnetism film [at least] may be exposed. moreover, the 1st flat-surface top of the 1st [after the manufacture method of the thin film magnetic head of this invention deletes the resist formed at the 2nd process] bias antiferromagnetism film -- a mushroom -- it has the 3rd process which forms a type resist and forms the electrode lead layer of a right-and-left couple Moreover, the manufacture method of the thin film magnetic head of this invention has the 4th process which forms a cap layer so that the portion top which the 1st flat surface of the electrode lead layer of the right-and-left couple formed on the bias antiferromagnetism film which has a level difference, and a bias antiferromagnetism film exposed may be covered. Moreover, the manufacture method of the thin film magnetic head of this invention On a lower gap insulating layer, laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer is carried out one by one. A type resist is formed. the 1st process which forms a magnetoresistance-effect element, and a free magnetic layer top -- a wrap -- like -- the 1st bias antiferromagnetism film -- forming membranes -- further -- a it top -- a wrap -- the cap layer top after forming a cap layer like -- a mushroom -- Shave off a part of cap layer at least, and membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple is carried out on it so that the 1st bias antiferromagnetism film may be xposed. The upper surface of the 1st bias antiferromagnetism film which touched the cap layer The 1st flat surface, The upper surface of the 2nd bias antiferromagnetism film is made into the 2nd flat surface, and the thickness of the portion of the 1st flat surface is the thickness of the 1st bias antiferromagnetism film. The 2nd process which forms the bias antiferromagnetism film which whose thickness of the portion of the 2nd flat surface is the sum of the thickness of the 1st bias antiferromagnetism film, and the thickness of the 2nd bias antiferromagnetism film, and has the level difference which has a thickness difference among them, On the 2nd bias antiferromagnetism film, it has the 3rd process which carries out membrane formation formation of the electrode lead layer of a right-and-left couple. moreover, the cap layer top after the manufacture method of the thin film magnetic head of this invention deletes the resist formed at the 2nd process -- a mushroom -- a type resist is formed and it has the 3rd process which carries out membrane formation formation of the electrode lead layer of a right-and-left couple Moreover, after the manufacture method of the thin film magnetic head of this invention deletes the resist formed at the 2nd process, it del tes a part of electrode lead layer membrane at least, and has the 3rd process which forms the electrode lead lay r of a right-and-left couple so that a 2nd bias antiferromagnetism film and cap layer top may be covered, an electrode lead layer membrane may be formed and a part of cap layer [at least] may be exposed.

[0015] By forming the antiferromagnetism film which has a level difference by the thickness difference by this method on a free magnetic layer A bias magnetic field strong against a portion (portions other than the width-of-recording-track portion of a free magnetic layer) to fix the magnetization direction to very strongly is applied. On the other hand, although a bias magnetic field must be applied in order to suppress a Barkhausen noise Applying the optimal bias magnetic field for a portion (the direction center section of the width of recording track of the free magnetic layer) not applying a not much strong magnetic field, since reproduction sensitivity will fall if a strong magnetic field is applied The magnetoresistance-effect type thin film magnetic head which can be easily controlled by thickness of the antiferromagnetism film of each portion is producible. That is, although the free magnetic layer which is in contact with the big portion of thickness on either side was combined by the joint magnetic field by very strong antiferromagnetism combination, the free magnetic layer is [near the head truck section / on the other hand] in contact with the small antiferromagnetism film of thickness and it is combined by the comparatively small antiferromagnetism joint magnetic field The direction of the magnetization will be turned to in the same direction as the big antiferromagnetism film of thickness, and the dir ction of the magnetization of a fre magnetic lay r which has th joint magnetic field by strong antiferromagnetism combination. The dir ction of the magnetization stabilized very much is obtained, and the magn toresistanc -effect type thin film head of high r producibility ability with high reproduction sensitivity with few noises can b produced. Furthermore, on the 1st antif rromagnetism film with which th upper surface was clean d, since membrane formation formation of th 2nd antif rromagnetism film is carri d out, b twe n the 1st antiferromagnetism film and th 2nd antif rromagnetism film, very good adh sion and a magn tic combination are stabilized, and are obtain d, and the magnet resistance-effect type thin film magnetic head by which th direction of magnetization of a free magnetic layer was stabilized very much can be produc d. Moreov r, by forming a cap layer, oxidization on the upper surface of an antiferromagnetism film can b prev nted, corrosion resistanc can also improv , and property degradation by them can produce th magnetor sistance-effect typ thin film magnetic head which was

excellent in few reproducibility ability.
[0016]
[Embodiments of the Invention] The vertical bias layer which invention of this invention according to claim 1 has a magnetoresistance-effect element through an insulating material between a lower shield layer and an up shield layer, and was prepared in contact with the aforementioned magnetoresistance-effect element, In the magnetoresistance-effect type thin film magnetic head which consists of an electrode lead layer for passing the signal current The magnetoresistance-effect element which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, It is characterized by having the composition which consists of a bias antiferromagnetism film which has the 1st flat surface with the level difference by the thickness difference, and the 2nd flat surface. moreover, invention of this invention according to claim 2 joint magnetic field by antiferromagnetism combination of the portion of the free magnetic layer which is in contact with the portion of the bias antiferromagnetism film which constitutes the 1st small flat surface of thickness 8 kA/m The following (below 100e) It is characterized by things. it is — A bias magnetic field strong against a portion (portions other than the width-of-recording-track portion of a free magnetic layer) to fix the magnetization direction to very strongly is applied. On the other hand, although a bias magnetic field must be applied in order to suppress a Barkhausen noise It becomes possible [controlling by thickness of the antiferromagnetism film of each portion easily] to apply the optimal bias magnetic field for a portion (the direction center section of the width of recording track of the free magnetic layer) not to apply a not much strong magnetic field, since reproduction sensitivity will fall if a strong magnetic field is applied. that is, to the free magnetic layer which is in contact with the antiferromagnetism film of the portion of the 2nd big flat surface of thickness The joint magnetic field by strong antiferromagnetism combination is acquired, and the direction of th magnetization becomes what was stabilized very much. The sake, Even if the joint magnetic field by antiferromagnetism combination of the portion of the free magnetic layer which is in contact with the antiferromagnetism film of the portion of the 1st small flat surface of thickness is small Become easy to be suitable in th direction of magnetization of the free magnetic layer which was stabilized and is in contact with the antiferromagnetism film of the portion of the 2nd big flat surface of thickness, and the direction of the same magnetization. Moreover, since the antiferromagnetism joint magnetic field of the portion of the free magnetic layer which is in contact with the antiferromagnetism film of the portion of the 1st small flat surface of thickness is small, By the external magnetic field, i.e., the magnetic field from a magnetic-recording medium, the direction of the magnetization becomes easy to change, there can be little generating of a Barkhausen noise, reproduction sensitivity can be high, and reproducibility ability can be stabilized. moreover, since there is no influence which is not concerned with gap length, but has the same effect, and this bias magnetic field has on a fixed magnetic layer in order to apply a bias magnetic field by the joint magnetic field with an antiferromagnetism film and the inclination of magnetization of the fixed magnetic layer by it is not produced, either, degradation of the symmetric property of an output wave is suppressed Moreover, by choosing the thickness of the antiferromagnetism film of the portion of the first flat surface the optimal, the joint magnetic field of an antiferromagnetism film and a free magnetic layer can be stabilized and given to the strength of 8 or less kA/m, and it has the operation that improvement in reproducibility ability can be aimed at.
[0017] Moreover, invention of this invention according to claim 3 carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer one by one on a lower gap insulating layer. So that the 1st process which forms a magnetoresistance-effect element, and a magnetoresistance-effect element top may be covered The 2nd process which forms a bias antiferromagnetism film with the level difference which consists of a portion with the small thickness which deletes a part of bias antiferromagnetism layer membrane, and has the 1st flat surface after forming a bias antiferromagnetism layer membrane, and a large portion of the thickness which has the 2nd flat surface, So that a bias antiferromagnetism film top may be covered and a part of 1st flat surface [at least] of a bias antiferromagnetism film may be [an electrode lead layer membrane may be formed and] exposed A part of electrode lead layer membrane is deleted at least, and it is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 4 A type resist is formed. the 3rd process of a claim 3 — setting — a 1st [of a bias antiferromagnetism film] flat-surface top — a mushroom — It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple on a bias antiferromagnetism film. moreover, invention of this invention according to claim 5 In the 2nd process of a claim 3, and the 3rd process, so that a free magnetic layer top may be covered With the 2nd process which forms a bias antiferromagnetism layer membrane, further, so that a it top may be covered So that a part of bias antiferromagnetism layer membrane may be shaved off and it may xpose, after forming an electrode lead layer membrane A part of electrode lead layer membrane and each bias antif rromagnetism layer membrane are deleted. The upper surface of the bias antiferromagnetism layer membrane which it was deleted and was exposed The 1st flat surface, It is characterized by having the 3rd process which forms th lectrode lead layer of a right-and-left couple on the 2nd [of the bias antiferromagnetism film which has a level difference by the thickness difference which makes the upper surface of the bias antiferromagnetism layer membrane at the time of membrane formation the 2nd flat surface, and a bias antiferromagnetism film] flat surface. again Inv ntion of this invention according to claim 6 carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer one by one on a lower gap insulating layer. So that the 1st process [which forms a magnetoresistance-effect element], and free magnetic layer top which constitutes a magnetoresistance-effect element may be covered A type resist is formed. the 1st bias antif rromagnetism film — forming membranes — the upper surface of the 1st bias antiferromagnetism film — a mushroom — The upper surface which carried out membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple, and has exposed the 1st bias antiferromagnetism film The 1st flat surface, The upper surface of the 2nd bias antiferromagn tism film is made into the 2nd flat surface, and the thickness of the portion of the 1st flat surface is th thickn ss of the 1st bias antiferromagn tism film. The 2nd process which forms th bias antif rromagn tism film which whose thickness of th portion of th 2nd flat surface is th sum of th thickn ss of the 1st bias antiferromagnetism film, and the thickn ss of the 2nd bias antif rromagnetism film, and has the level difference which has a thickness difference among them, It is characteriz d by having th 3rd process which carries out membran formation formation of the lectrode lead layer of a right-and-l ft couple on the 2nd bias antiferromagnetism film. mor over, invention of this inv ntion according to claim 8 So that the 2nd bias antiferromagnetism film top of the portion which th 1st bias antiferromagnetism film xp sed, and a right-and-left coupl may b cover d, after deleting the resist form d at the 2nd process in th 3rd process of a claim 6 So that an electrode l ad layer membrane may be form d and a part of 1st bias antiferromagnetism film [at least] may be xposed A part of lectrode l ad layer

membrane is deleted at least, and it is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 9 A type resist is formed. the 1st flat-surface top of the 1st [after deleting the resist formed at the 2nd process in the 3rd process of a claim 6] bias antiferromagnetism film -- a mushroom -- It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. A bias magnetic field strong against a portion (portions other than the width-of-recording-track portion of a free magnetic layer) to fix the magnetization direction to very strongly is applied. On the other hand, although a bias magnetic field must be applied in order to suppress a Barkhausen noise Applying the optimal bias magnetic field for a portion (the direction center section of the width of recording track of the free magnetic layer) not applying a not much strong magnetic field, since reproduction sensitivity will fall if a strong magnetic field is applied The magnetoresistance-effect type thin film magnetic head which can be easily controlled by thickness of the antiferromagnetism film of each portion is producible. That is, by forming the antiferromagnetism film which has a level difference by the thickness difference on a free magnetic layer Although the free magnetic layer which is in contact with the big portion of thickness on either side is combined by the joint magnetic field by very strong antiferromagnetism combination, and the free magnetic layer is [near the head truck section] in contact with the small antiferromagnetism film of thickness on the other hand and it is combined by the comparatively small antiferromagnetism joint magnetic field The direction of the magnetization will be turned to in the same direction as the big antiferromagnetism film of thickness, and the direction of the magnetization of a free magnetic layer which has the joint magnetic field by strong antiferromagnetism combination. The direction of the magnetization stabilized very much is obtained, and it has the operation that the magnetoresistance-effect type thin film head of high reproducibility ability with high reproduction sensitivity with few noises is producible.

[0018] Moreover, invention of this invention according to claim 7 is set at the 2nd process of a claim 6. A type resist is formed. the free magnetic layer top which constitutes a magnetoresistance-effect element -- a wrap -- like -- the 1st bias antiferromagnetism film -- forming membranes -- the upper surface of the 1st bias antiferromagnetism film -- a mushroom -- After cleaning the upper surface of the 1st bias antiferromagnetism film, membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple is carried out. The 1st flat surface and the upper surface of the 2nd bias antiferromagnetism film are made into the 2nd flat surface for the upper surface which has exposed the 1st bias antiferromagnetism film. By being characterized by having the 2nd process which forms a bias antiferromagnetism film with the level difference by the thickness difference between the 1st flat surface and the 2nd flat surface, and forming the antiferromagnetism film which has a level difference by the thickness difference on a free magnetic layer The direction of the magnetization stabilized very much in the free magnetic layer will be obtained, and since membrane formation formation of the 2nd antiferromagnetism film is carried out on the 1st antiferromagnetism film with which the upper surface was cleaned, further between the 1st antiferromagnetism film and the 2nd antiferromagnetism film Very good adhesion and a magnetic combination are stabilized, and are obtained, the direction of magnetization of a free magnetic layer becomes what was stabilized very much, and it has the operation that the magnetoresistance-effect type thin film head of high reproducibility ability with high reproduction sensitivity with few noises is producible.

[0019] Moreover, invention of this invention according to claim 10 so that the portion top which the 1st flat surface of the lectrode lead layer of the right-and-left couple formed on the bias antiferromagnetism film which has a level difference, and a bias antiferromagnetism film exposed may be covered It is characterized by having the 4th process which forms a cap layer. moreover, invention of this invention according to claim 11 On a lower gap insulating layer, laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a non-magnetic layer, and the free magnetic layer is carried out one by one. A type resist is formed. the 1st process which forms a magnetoresistance-effect element, and a free magnetic layer top -- a wrap -- like -- the 1st bias antiferromagnetism film -- forming membranes -- further -- a it top -- a wrap -- the cap layer top after forming a cap layer like -- a mushroom -- Shave off a part of cap layer at least, and membrane formation formation of the 2nd bias antiferromagnetism film of a right-and-left couple is carried out on it so that the 1st bias antiferromagnetism film may be xposed. The upper surface of the 1st bias antiferromagnetism film which touched the cap layer The 1st flat surface, The upper surface of the 2nd bias antiferromagnetism film is made into the 2nd flat surface, and the thickness of the portion of the 1st flat surface is the thickness of the 1st bias antiferromagnetism film. The 2nd process which forms the bias antiferromagnetism film which whose thickness of the portion of the 2nd flat surface is the sum of the thickness of the 1st bias antiferromagnetism film, and the thickness of the 2nd bias antiferromagnetism film, and has the level difference which has a thickness difference among them, It is characterized by having the 3rd process which carri s out membrane formation formation of the electrode lead layer of a right-and-left couple on the 2nd bias antif rromagnetism film. moreover, invention of this invention according to claim 12 A type resist is formed. the cap layer top after deleting the resist formed at the 2nd process in the 3rd process of a claim 11 -- a mushroom -- It is characterized by having the 3rd process which carries out membrane formation formation of the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 13 After deleting the resist formed at the 2nd process in the 3rd process of a claim 11, so that a 2nd bias antiferromagnetism film and cap layer top may be cov red So that an electrode lead layer membrane may be formed and a part of cap layer [at least] may be exposed By deleting a part of electrode lead layer membrane at least, being characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple, and forming the antiferromagnetism film which has a level diff rence by the thickness difference on a free magnetic layer By obtaining the direction of the magnetization stabilized very much in the free magnetic layer, and forming a cap layer on the portion which has exposed the bias antif rromagnetism film further at least Oxidization of the portion which the bias antiferromagnetism film exposed can be prevented, corrosion resistance can be raised, and it has the operation that there is little property degradation by them and it can produce the magnetoresistance- ffect type thin film head of high reproducibility ability with high reproduction sensitivity with few nois s.

[0020] Her after, th gestalt of operation of this invention is explained using a drawing.

[0021] (Gestalt 1 of operation) Drawing 1 and drawing 2 are outline explanatory drawings showing the outlin of the gestalt 1 of operation of this invention, and the transverse-plane outlin diagram which looked at drawing 1 fr m the head sliding-surface sid which counters a magn tic-recording m dium, and drawing 2 ar som transvers -plane outline diagrams of the thin film magnetic head s en from the head sliding-surfac side which counters a magnetic-recording medium.

[0022] On the lower gap insulating layer (not shown) using the nonmagn tic insulating material of aluminum2O3 formed in drawing 1 on lower shield layer (not shown) made from soft magn tic materials, such as permalloy, Co system

amorphous magnetic-film, or Fe system particle magnetic film, AlN, or SiO2 grade The antiferromagnetism layer 1, NiFe system alloy film which are material, such as IrMn, alphaFe2O4, NiO, a FeMn system alloy film, and a PtMn system alloy film The magnetoresistance-effect element 5 (MR element or GMR element.) which consisted of a non-magnetic layer 3 and the fixed magnetic layer 2 made from the fixed magnetic layer 2 made from Co, a CoFe alloy film, etc., Cu, etc., and a free magnetic layer 4 made from the same ferromagnetic material a following and GMR element -- saying -- it is constituted Furthermore, the bias antiferromagnetism film 8 is formed using the antiferromagnetism material (it is better not to use a metal oxide film depending on the case) of different sp cies [layer / antiferromagnetism / 1] having / and / the level difference which has the 1st flat surface 6 and the 2nd flat surface 7 in the upper surface of the free magnetic layer 4 at the topmost part which constitutes the GMR element 5 when thickness differs. Furthermore, the electrode lead layer 9 of a right-and-left couple is formed on the bias antiferromagnetism film 8.

[0023] In addition, it is desirable to form the cap layer 10 by being made from non-magnetic materials, such as Ta, to prevent oxidization of the portion which the bias antiferromagnetism film 8 exposed, and to raise corrosion resistance on the portion which has exposed the electrode lead layer 9 of a right-and-left couple and the bias antiferromagnetism film 8.

[0024] As for each heat treatment (annealing processing) to the antiferromagnetism layer 1 or the bias antiferromagnetism film 8 which adds the direction of magnetization to each of the fixed magnetic layer 2 or the free magnetic layer 4, it is good to carry out, after the cap layer 10 is formed, and before patterning of the cap layer 10, the electrode lead layer 9, and the bias antiferromagnetism film 8 is carried out to a predetermined configuration and they are shaved off. Moreover, the heat treatment conditions of the bias antiferromagnetism film 8 for adding the direction of magnetization to the heat treatment conditions and free magnetic layer of the antiferromagnetism layer 1 for setting the direction of magnetization as the fixed magnetic layer 2 must select each material of the antiferromagnetism layer 1 and the bias antiferromagnetism film 8 so that at least one conditions of magnetic field strength, heat treatment temperature, and heat treatment time may differ.

[0025] The fixed magnetic layer 2 carries out antiferromagnetism combination strongly with the antiferromagnetism layer 1, and the direction of the magnetization is being strongly fixed in the direction (direction right-angled in space) of Y by the joint magnetic field. On the other hand, although it is magnetized so that the free magnetic layer 4 may be combined by the joint magnetic field by the bias antiferromagnetism film 8 and antiferromagnetism combination which have a level difference by the thickness difference on the upper surface and the direction of the magnetization may become in the direction of X (the direction of the width of recording track) The portion of the free magnetic layer 4 which the joint magnetic field strength by the antiferromagnetism combination will differ, and is in contact with the bias antiferromagnetism film 8 of the portion of the 1st small flat surface 6 of thickness with the thickness of the bias antiferromagnetism film 8, In the portion of the free magnetic layer 4 which is in contact with the bias antiferromagnetism film 8 of the portion of the 2nd large flat surface 7 of thickness, a difference arises in the joint magnetic field strength. It has the property that it will be saturated if the joint magnetic field also becomes large and generally becomes beyond a certain range as thickness becomes large, and the change property changes with material of the bias antiferromagnetism film 8.

[0026] Drawing 3 is drawing which carried out the simulation of the relation of a reproduction output to the joint magnetic field strength concerning a free magnetic layer, as compared with the case where the magnetic field strength added to the free magnetic layer is very strong, the direction when small is very high and a reproduction output understands a bird clapper. Especially, the output is improving rapidly [kA / 8 //m / or less (100 or less Oes)].

[0027] Therefore, it sets into the portion of the free magnetic layer 4 which is in contact with the bias antiferromagnetism film 8 of the portion of the 1st small flat surface 6 of thickness. The heat treatment conditions which give the direction of magnetization to the 1st plane thickness and plane free magnetic layer of a portion of a bias antiferromagnetism film (in the strength of a magnetic field) When setting up suitably heat treatment temperature and heat treatment time and making it the joint magnetic field by the antiferromagnetism combination with a bias antiferromagnetism film and the free magnetic layer of the portion of the 1st flat surface become 8 or less (100 or less Oes) kA/m, a high reproduction output can be obtained.

[0028] Moreover, the fixed magnetic layer 2 which constitutes the GMR element 5 may be the laminating fixed magnetic layer 24 which has the composition by which laminating membrane formation of the 1st fixed magnetic layer film 21, the non-magnetic layer film 22, and the 2nd fixed magnetic layer film 23 was carried out on the antiferromagnetism layer 1, as shown in drawing 2 (a). At this time, the direction of magnetization of the 1st fixed magnetic layer film 21 which counters through the non-magnetic layer film 22 by the thickness of the non-magnetic lay r film 22 which intervenes between the 1st fixed magnetic layer film 21 and the 2nd fixed magnetic layer film 23, and the 2nd fixed magnetic layer film 23 becomes in the respectively same direction, or becomes each other in the reverse direction.

[0029] Moreover, as shown in drawing 2 (b), the free magnetic layer 4 which constitutes the GMR element 5 The same mat rial as the free magnetic layer 4 is used. The 1st free magnetic layer film 25, the 2nd free magnetic layer film 26, ..., The material of the free magnetic layer film which laminating membrane formation is carried out one by one with the n-th free magnetic layer film 27, and adjoins each other cannot be overemphasized by that the laminating free magnetic layer 28 currently formed by each using a material of a different kind is sufficient.

[0030] In addition, in the gestalt 1 of this operation, although the so-called GMR element using nonmagnetic electric conduction material, such as Cu, as a non-magnetic layer which constitutes a magnetoresistance-effect element has been xplained, it is needless to say that the composition of an electrode lead layer etc. can be changed also to the so-called TMR element using the nonmagnetic insulating material of aluminum2O3 grade as a non-magnetic layer, and this invention can be applied.

[0031] According to th gestalt 1 of this operation, a bias magnetic field strong against a portion (portions other than the width-of-recording-track portion of a free magnetic lay r) to fix the magn tization direction to very strongly is applied as mentioned above. On th other hand, although a bias magn tic field must be applied in order to suppress a Barkhausen noise It becomes possible [controlling by thickness of th antif rromagn tism film of each portion easily] to apply the optimal bias magnetic field for a portion (width-of-recording-track portion of a free magnetic layer) not to apply a not much strong magn tic field, since reproduction s nsitivity will fall if a strong magnetic fi ld is appli d. that is, to the free magnetic layer which is in contact with th antiferromagnetism film of the portion of the 2nd big flat surface of thickness The joint magnetic field by strong antif rromagnetism combination is acquired, and th direction of the magn tization becomes what was stabiliz d very much. Th sak , Even if the joint magnetic field by antiferromagn tism combination of the portion of the fre magnetic lay r which is in contact with the

antiferromagnetism film of the portion of the 1st small flat surface of thickness is small Become easy to be suitable in the direction of magnetization of the free magnetic layer which was stabilized and is in contact with the antiferromagnetism film of the portion of the 2nd big flat surface of thickness, and the direction of the same magnetization. Moreover, since the antiferromagnetism joint magnetic field of the portion of the free magnetic layer which is in contact with the antiferromagnetism film of the portion of the 1st small flat surface of thickness is small, By the external magnetic field, i.e., the magnetic field from a magnetic-recording medium, the direction of the magnetization becomes easy to change, ther can be little generating of a Barkhausen noise, reproduction sensitivity can be high, and reproducibility ability can be stabilized. moreover, since there is no influence which is not concerned with gap length, but has the same effect, and this bias magnetic field has on a fixed magnetic layer in order to apply a bias magnetic field by the joint magnetic field with a bias antiferromagnetism film and the inclination of magnetization of the fixed magnetic layer by it is not produced, either, degradation of the symmetric property of an output wave is suppressed Moreover, by choosing the thickness of the antiferromagnetism film of the portion of the first flat surface the optimal, the joint magnetic field of an antiferromagnetism film and a free magnetic layer can be stabilized and given to the strength of 8 or less kA/m, and improvement in reproducibility ability can be aimed at.

[0032] Moreover, between two fixed magnetic layer films which counter through a non-magnetic layer film by stabilizing the direction of the magnetization by the joint magnetic field with an antiferromagnetism layer very much, and choosing the thickness of a non-magnetic layer film in the suitable range by making it a laminating fixed magnetic layer It can be made to join together strongly in antiferromagnetism, the direction of magnetization is fixed strongly, and the direction of each other magnetization becomes in the reverse direction, the leakage magnetic field by end-face magnetic charge is suppressed, and the direction of the magnetization in an end face also becomes what was stabilized very much.

[0033] (Form 2 of operation) Drawing 4 - drawing 11 are outline explanatory drawings showing the form 2 of operation of this invention, are process outline explanatory drawing for explaining the manufacturing process of the magnetoresistance-effect type thin film magnetic head for reproduction, and are the outline cross section which made it the cross section near the head sliding surface which counters a magnetic-recording medium in respect of being parallel to a head sliding surface. Hereafter, the manufacture method of the magnetoresistance-effect type thin film magnetic head for reproduction is explained in order of each process using a drawing.

[0034] As shown in drawing 4 , membranes are formed on the substrate 40 made from AlTiC etc., and the nonmagnetic insulating material of aluminum2O3, AlN, or SiO2 grade is used on the lower shield layer 41 made from soft magnetic materials, such as a permalloy, Co system amorphous magnetic film, or Fe system particle magnetic film, and the lower gap insulating layer 42 is formed.

[0035] As shown in drawing 5 (a), as the 1st process next, on the lower gap insulating layer 42 As the antiferromagnetism layer 51 is formed using material, such as IrMn, alphaFe2O3, NiO, a FeMn system alloy film, a NiMn system alloy film, or a PtMn system alloy film, and it is further shown in drawing 5 (b) Moreover, the fixed magnetic layer 52 is formed by being made from a NiFe system alloy film, Co, or a CoFe alloy film. Next, as shown in drawing 5 (c), the non-magnetic layer 53 made from Cu etc. is formed on the fixed magnetic layer 52. Furthermore, as shown in drawing 5 (d), on a non-magnetic layer 53, the free magnetic layer 54 is formed using the same material as the fixed magnetic layer 52, and the GMR element 55 by which laminating membrane formation of the antiferromagnetism layer 51, the fixed magnetic layer 52, a non-magnetic layer 53, and the free magnetic layer 54 was carried out one by one by the thin film is formed.

[0036] Antiferromagnetism material of different species [layer / antiferromagnetism / 51 / which constitutes the GMR element 55 on the GMR element 55 as the 2nd process as shown in drawing 6 (a)] (however, depending on the case) alphaFe2 -- the way which does not use metal oxide material, such as O3 and NiO, -- being good, as shown in drawing 6 (b), after using and forming the bias antiferromagnetism layer membrane 61 [near the portion which forms, the abbreviation center section, i.e., the head width of recording track, of the GMR element 55 and the bias antiferromagnetism layer membrane 61,] Apply a photoresist and a part of bias antiferromagnetism layer membrane 61 is shaved off by methods, such as dry etching. The antiferromagnetism film 64 with the level difference which has the 2nd large flat surface 63 of the thickness the 1st flat surface 62 to which it is shaved off and thickness is small, and right and left are not shaved [thickness] is formed.

[0037] As the 3rd process, as are shown in drawing 7 (a), and the electrode lead layer membrane 71 is formed on the bias antiferromagnetism film 64 with a level difference using non-magnetic materials, such as Cu, Cr, or Ta, and it is shown in drawing 7 (b) A photoresist is applied, by methods, such as dry etching, a part of electrode lead layer membrane 71 is shaved off at least, and the electrode lead layer 72 of a right-and-left couple is formed so that a part of 1st flat surface 62 of the small portion of the thickness of the bias antiferromagnetism film 64 may be exposed. As the 4th process, as shown in drawing 8 , on the portion which a part of 1st flat surface 62 of the electrode lead layer 72 of a right-and-left couple and the bias antiferromagnetism film 64 exposed, material, such as Ta, is used and the cap layer 81 is formed.

[0038] Next, although not illustrated, carry out patterning of the cap layer 81, the electrode lead layer 72 of a right-and-left couple, and the bias antiferromagnetism film 64 to a predetermined configuration, and they are shaved off. Furthermore, on them, an up gap insulating layer is formed using the same insulating material as the lower gap insulating layer 42, further, on it, membrane formation formation of the up shield layer is carried out using the same soft magn tic materials as the lower shield layer 41, and the magnetoresistance-effect type thin film magnetic head for reproduction is produced.

[0039] As shown in drawing 9 (a), as the 1st above-mentioned process moreover, on the lower gap insulating layer 42 The antiferromagnetism layer 51 is formed. on it further A NiFe system alloy film, Laminating membrane formation of the 1st non-magnetic layer film 902 and the 1st fixed magnetic layer film 901 using the non-magnetic materials made from Co or the CoFe alloy film, such as the 1st fixed magnetic layer film 901 and Ru, and the 2nd fixed magnetic lay r film 903 using the same material is carried out one by one. The laminating fixed magn tic layer 91 is formed, on it, the non-magn tic layer 53 made from Cu etc. and the fre magnetic layer 54 using the material of the 1st fixed magnetic layer film 901 grade and the sam material may be formed one by one, and the GMR lem nt 92 may b formed.

[0040] As shown in drawing 9 (b), as the 1st abov -mentioned process moreover, on th low r gap insulating layer 42 Th antif rr magnetism layer 51, the fixed magnetic layer 52, and a non-magnetic lay r 53 are formed one by on . furth r Laminating m mbrane formation of the 1st free magnetic layer film 911, the 2nd free magnetic layer film 912, ..., the n-th fr e magnetic layer film 913 (n is two or mor positive int gers) may be carried out one by one on it, the laminating fre magn tic layer 93 may be form d, and the GMR element 94 may b formed.

[0041] mor over, wh n the equipm nt which carries out laminating m mbrane formation and forms the GMR element 55

at the 1st process differs from the equipment which forms the bias antiferromagnetism layer membrane 61 at the 2nd process After cleaning the upper surface of the free magnetic layer 54 by methods, such as a pulley spatter by Ar etc., or efficient consumer response, as the 2nd process and removing an oxide film, a foreign matter, or dirt of the free magnetic layer 54 on top etc., as shown in drawing 6 It is more desirable to have formed the bias antiferromagnetism layer membrane 61 and to form the bias antiferromagnetism film 64 with th level difference which shaves off a part of bias antiferromagnetism layer membrane 61, and has a thickness difference by methods, such as dry etching. There is no mediation of a foreign matter between the free magnetic layer 54 and th bias antif rromagnetism film 64 by cleaning the upper surface of the free magnetic layer 54 at this time, and th joint magnetic field stabilized more can be acquired, without the joint magnetic field strength of the bias antiferromagnetism film 64 and the free magnetic layer 54 falling, since very good adhesion and a magnetic combination are stabilized and are obtained.

[0042] moreover, the 3rd above-mentioned process is shown in drawing 10 — as — the 1st flat-surface 62 top of the bias antiferromagnetism film 64 — a mushroom — the type resist 101 may be formed and membrane formation formation of the electrode lead layer 102 of a right-and-left couple may be carried out on the bias antiferromagnetism film 64

[0043] Moreover, in the 2nd process and the 3rd process, as shown in drawing 6 (a) like the 2nd above-mentioned process as the 2nd process After forming the bias antiferromagnetism layer membrane 61 so that the free magnetic layer 54 top may be covered, as shown in drawing 11 (a), as the 3rd process Furthermore, as the electrode lead layer membrane 111 is formed and it is shown in drawing 11 (b) so that a it top may be covered Apply a photoresist and a part of electrode lead layer membrane 111 and bias antiferromagnetism layer membrane 61 are shaved off by methods, such as dry etching. You may form the electrode lead layer 115 of a right-and-left couple on the 2nd flat surface 113 of the bias antiferromagnetism film 114 with a level difference with which the thickness of a center section has the 1st small flat surface 112, and has the 2nd large flat surface 113 of thickness right and left, and the bias antiferromagnetism film 114. In addition, before forming the bias antiferromagnetism layer membrane 61, it cannot be overemphasized that the upper surface of the free magnetic layer 54 may be cleaned.

[0044] According to the gestalt 2 of this operation, a bias magnetic field strong against a portion (portions other than the width-of-recording-track portion of a free magnetic layer) to fix the magnetization direction to very strongly is applied as mentioned above. On the other hand, although a bias magnetic field must be applied in order to suppress a Barkhausen noise Applying the optimal bias magnetic field for a portion (width-of-recording-track portion of a free magnetic layer) not applying a not much strong magnetic field, since reproduction sensitivity will fall if a strong magnetic field is applied The magnetoresistance-effect type thin film magnetic head which can be easily controlled by thickness of the antiferromagnetism film of each portion is producible. That is, the joint magnetic field of a bias antiferromagnetism film and a free magnetic layer which carried out antiferromagnetism combination changes with the thickness of a bias antiferromagnetism film. Namely, the property that the joint magnetic field will be saturated if a joint magnetic field becomes large and becomes the above thickness to some extent so that the thickness of a bias antiferromagnetism film is large is used. By forming the bias antiferromagnetism film which has a level difference by the thickness difference on a free magnetic layer Although the free magnetic layer which is in contact with the big portion of thickness on either side is combined by the very strong joint magnetic field, and the free magnetic layer is [near the head truck section] in contact with the small bias antiferromagnetism film of thickness on the other hand and it is combined by the comparatively small joint magnetic field The direction of the magnetization will be turned to in the same direction as the big bias antiferromagnetism film of thickness, and the direction of the magnetization of a free magnetic layer which has the strong joint magnetic field. The direction of the magnetization stabilized very much will be obtained, and the magnetoresistance-effect type thin film head of high reproducibility ability with high reproduction sensitivity with few noises can be produced. moreover, since there is no influence which is not concerned with gap length, but has the same effect, and this bias magnetic field has on a fixed magnetic layer in order to apply a bias magnetic field by the joint magnetic field with a bias antiferromagnetism film and the inclination of magnetization of the fixed magnetic layer by it is not produced, either, the magnetoresistance-effect type thin film head by which degradation of the symmetric property of an output wave was suppressed is producible

[0045] In addition, by forming a cap layer, oxidization of the portion which the bias antiferromagnetism film exposed can be prevented, and corrosion resistance can be raised.

[0046] Moreover, as for each heat treatment (annealing processing) to the antiferromagnetism layer or bias antiferromagnetism film which adds the direction of magnetization to each of a fixed magnetic layer or a free magnetic layer, it is good to carry out, after a cap layer is formed, and before patterning of a cap layer, an electrode lead layer, and the bias antiferromagnetism film is carried out to a predetermined configuration and they are shaved off. Moreover, the heat treatment conditions of the bias antiferromagnetism film for adding the direction of magnetization to the heat treatment conditions and free magnetic layer of an antiferromagnetism layer for setting the direction of magnetization as a fixed magnetic layer must select each material of an antiferromagnetism layer and a bias antiferromagnetism film so that at least one conditions of magnetic field strength, heat treatment temperature, and heat treatment time may differ.

[0047] In addition, by forming a laminating fixed magnetic layer, the leakage magnetic field by the end-face magnetic charge of the fixed magnetic layer by which the direction of magnetization was strongly fixed in the predetermined direction will be negated by the fixed magnetic layer film formed through the non-magnetic layer film, and an effect is to stop a noise.

[0048] (Gestalt 3 of operation) Drawing 12 - drawing 16 are outline explanatory drawings showing the gestalt 3 of operation of this invention, are process outline explanatory drawing for explaining the manufacturing process of the magnetoresistance-effect type thin film magnetic head for reproduction, and are the outline cross section which mad it the cross section near the h ad sliding surface which counters a magn tic-r cording medium in resp ct of being parallel to a head sliding surfac . Hereafter, the manufacture method of the magn toresistanc - ff ct type thin film magnetic head for r production is explain d in order of ach process using a drawing.

[0049] Lik the form 2 of the abov -mentioned operation, as the 1st process, as shown in drawing 5 (a) As material, such as IrMn, alphaF 2O3, NiO, a FeMn syst m alloy film, a NiMn syst m alloy film, or a PtMn system alloy film, is used, the antiferromagnetism lay r 51 is formed on th lower gap insulating lay r 42 and it is further shown in drawing 5 (b) Moreover, the fixed magnetic layer 52 is formed by being made from a NiFe system alloy film, Co, or a CoF alloy film. Next, as shown in drawing 5 (c), th non-magnetic layer 53 made from Cu etc. is formed on the fixed magn tic layer 52. Furthermore, as shown in drawing 5 (d), on a non-magn tic layer 53, th free magnetic layer 54 is form d using the same mat rial as the fixed magn tic layer 52, and th GMR element 55 by which laminating membran formati n of th

antiferromagnetism layer 51, the fixed magnetic layer 52, a non-magnetic layer 53, and the free magnetic layer 54 was carried out one by one by the thin film is formed.
[0050] The 1st bias antiferromagnetism film 121 is formed using the antiferromagnetism material (however, it is better not to use metal oxide material, such as alphaFe2O3 and NiO, depending on the case) of different species [layer / antiferromagnetism / 51 / which constitutes the GMR element 55 on the GMR element 55 as shown in drawing 12 (a) as the 2nd process]. The type resist 122 is formed. next, it is shown in drawing 12 (b) -- as -- a mushroom -- On the 1st bias antiferromagnetism film 121, membrane formation formation of the 2nd bias antiferromagnetism film 123 of a right-and-left couple is carried out using the same antiferromagnetism material as the 1st bias antiferromagnetism film 121. It has the 1st flat surface 124 which is the upper surface of the 1st bias antiferromagnetism film 121, and the 2nd flat surface 125 which is the upper surface of the 2nd bias antiferromagnetism film 123 formed on the 1st bias antiferromagnetism film 121. In the 1st flat-surface section, the thickness is the thickness of the 1st bias antiferromagnetism film 121 itself. In the 2nd flat-surface section, it is the sum of each thickness of the 1st bias antiferromagnetism film 121 and the 2nd bias antiferromagnetism film 123, and the bias antiferromagnetism film 126 which has a level difference by the thickness difference can be formed. Here, the material of the 1st bias antiferromagnetism film 121 and the 2nd bias antiferromagnetism film 123 must be chosen so that it may differ in the heat treatment conditions of the antiferromagnetism layer 51 for the heat treatment conditions (the magnetic field strength, heat treatment temperature, and heat treatment time to add) for adding the direction of magnetization to the free magnetic layer 54 adding the direction of magnetization to the fixed magnetic layer 52, and at least one condition. Moreover, the material of the 1st bias antiferromagnetism film 121 and the 2nd bias antiferromagnetism film 123 may be an antiferromagnetism material of a different kind, as long as a joint magnetic field with a free magnetic layer becomes larg by forming the 2nd antiferromagnetism film 123, and it is necessary at this time to heat-treat on the conditions suitable for the 1st bias antiferromagnetism film 121 and the 2nd bias antiferromagnetism film 123.
[0051] as the 3rd process, it is shown in drawing 13 -- as -- a mushroom -- using the type resist 122, on the 2nd bias antif rromagnetism film 123 of a right-and-left couple, non-magnetic materials, such as Cu, Cr, or Ta, are used, and m mbrane formation formation of the electrode lead layer 131 of a right-and-left couple is carried out
[0052] As the 4th process, as shown in drawing 14 , on the portion which the electrode lead layer 131 of a right-and-left couple and the 1st bias antiferromagnetism film 121 exposed, material, such as Ta, is used and the cap lay r 141 is formed.
[0053] Next, although not illustrated, carry out patterning of the cap layer 141, the electrode lead layer 131 of a right-and-left couple, and the bias antiferromagnetism film 126 to a predetermined configuration, and they are shaved off. Furthermore, on them, an up gap insulating layer is formed using the same insulating material as the lower gap insulating layer 42, further, on it, membrane formation formation of the up shield layer is carried out using the same soft magnetic materials as the lower shield layer 41, and the magnetoresistance-effect type thin film magnetic head for reproduction is produced.
[0054] In addition, it cannot be overemphasized that a laminating fixed magnetic layer or a laminating free magnetic layer can be formed, and a GMR element can be formed like other examples of the 1st process of the form 2 of the above-mentioned operation.
[0055] The type resist 122 is formed. moreover, it is shown in drawing 12 (b) as other examples of the 2nd process -- as -- a mushroom -- The upper surface of the 1st bias antiferromagnetism film 121 is cleaned by methods, such as a pulley spatter by Ar etc., or efficient consumer response. The oxide film of the front face of the 1st bias antiferromagnetism film 121, the remnants of a resist, After removing a foreign matter or dirt, the 2nd bias antiferromagnetism film 123 of a right-and-left couple by carrying out membrane formation formation on the 1st bias antiferromagnetism film 121 using the same antiferromagnetism material as the 1st bias antiferromagnetism film 121 Since there is no intervention of a foreign matter between the 1st bias antiferromagnetism film 121 and the 2nd bias antiferromagnetism film 123, and very good adhesion and a magnetic combination are stabilized and are obtained, The joint magnetic field stabilized more can be acquired without the joint magnetic field strength of a bias antiferromagnetism film and a free magnetic layer falling.
[0056] moreover, like other examples of the 2nd process of the form 2 of the above-mentioned operation as other examples of the 2nd process When the equipment which forms the 1st bias antiferromagnetism layer membrane 61 in the 2nd process differs from the equipment which forms the GMR element 55 in the 1st process The upper surface of the free magnetic layer 54 is cleaned by methods, such as a pulley spatter by Ar etc., or efficient consumer response. It is made to be the same as that of the 2nd process shown in drawing 12 , after removing the oxide film of the front fac of the free magnetic layer 54, the remnants of a resist, a foreign matter, or dirt. the cleaned free magnetic layer 54 top -- a wrap -- like -- the 1st bias antiferromagnetism film 121 -- forming membranes -- a it top -- a mushroom -- it is better to have formed the type resist 122 and to carry out membrane formation formation of the 2nd bias antiferromagnetism film 123 of a right-and-left couple The joint magnetic field stabilized more can be acquired like the form 2 of the above-mentioned operation, without the joint magnetic field strength of a bias antiferromagnetism film and a free magnetic layer falling.
[0057] moreover, the mushroom formed at the 2nd process as other examples of the 3rd process, as shown in drawing 15 (a), after deleting a type resist So that the portion top which the 2nd bias antiferromagnetism film 123 of a right-and-left couple and the 1st bias antiferromagnetism film 121 exposed may be covered As the electrode lead lay r membrane 151 is formed and it is shown in drawing 15 (b), so that a part of 1st flat surface 124 of the 1st bias antiferromagnetism film 121 may be exposed A photoresist is applied, by methods, such as dry etching, a part of el ctrode lead layer membrane 151 may be deleted at least, and the electrode lead layer 152 of a right-and-left couple may be formed.
[0058] mor over, the mushroom formed at the 2nd process as other examples of the 3rd pr c ss -- aft r deleting a typ resist, it is shown in drawing 16 -- as -- anoth r mushroom on the 1st bias antif rromagnetism film 121 -- the type resist 161 may be formed and membrane formation formation of the electrode lead layer 162 of a right-and-left couple may be carri d out
[0059] According to the form 3 of this peration, as menti ned abov like the form 2 of the above-mentioned operation The free magnetic layer which is in contact with the big bias antiferromagnetism film of thickn ss carri s out antiferromagn tism combination with a bias antif rromagnetism film by the very strong joint magnetic field. The dir ction of magn tization of the fre magnetic layer which is in contact with the small bias antif rromagn tism film of thickness Will stabilize and be suitable t wards th sam magnetization as the free magnetic layer which is in contact with the big bias antiferromagnetism film of thickness. On the 1st antiferromagnetism film with which th direction of

the magnetization stabilized very much was obtained, and the upper surface was cleaned, by carrying out membrane formation formation of the 2nd antiferromagnetism film between the 1st antiferromagnetism film and the 2nd antiferromagnetism film Very good adhesion and a magnetic combination are stabilized, and are obtained, and the direction of the magnetization of a free magnetic layer which has the joint magnetic field by the big antiferromagnetism film of thickness and strong antiferromagnetism combination becomes what was stabilized very much. The magnetoresistance-effect type thin film head of high reproducibility ability with high reproduction sensitivity with few noises is producible. mor over, since there is no influence which is not concerned with gap length, but has the same eff ct, and this bias magnetic field has on a fixed magnetic layer in order to apply a bias magnetic field by the joint magnetic field with a bias antiferromagnetism film and the inclination of magnetization of the fixed magnetic layer by it is not produced, either, the magnetoresistance-effect type thin film head by which degradation of the symmetric property of an output wave was suppressed is producible

[0060] In addition, in the form 3 of the form 2 of the above-mentioned operation - operation, after a cap layer is formed, and before patterning of a cap layer, an electrode lead layer, a bias antiferromagnetism film, and the GMR element is carried out to a predetermined configuration and they are shaved off as the 4th process, as for heat treatment which adds the direction of magnetization to a fixed magnetic layer and a free magnetic layer in the predetermined direction, respectively, it is desirable to carry out. It cannot be overemphasized by the heat treatment conditions (magnetic field strength, processing temperature, and processing time) to the antiferromagnetism layer which adds the direction of magnetization to a fixed magnetic layer here, and the heat treatment conditions to the bias antiferromagnetism film which adds the direction of magnetization to a free magnetic layer that the material of the bias antiferromagnetism film which touches the antiferromagnetism layer and free magnetic layer which touch a fixed magnetic layer, respectively must be chosen so that at least one condition items may differ.

[0061] (Form 4 of operation) Drawing 17 - drawing 20 are outline explanatory drawings showing the form 4 of operation of this invention, are process outline explanatory drawing for explaining the manufacturing process of the magnetoresistance-effect type thin film magnetic head for reproduction, and are the outline cross section which made it the cross section near the head sliding surface which counters a magnetic-recording medium in respect of being parallel to a head sliding surface. Hereafter, the manufacture method of the magnetoresistance-effect type thin film magnetic head for reproduction is explained in order of each process using a drawing.

[0062] Like the 1st process of the form 2 of the above-mentioned operation, as shown in drawing 5 , the antiferromagnetism layer 51, the fixed magnetic layer 52, a non-magnetic layer 53, and the free magnetic layer 54 form the GMR element 55 by which laminating membrane formation was carried out one by one.

[0063] As the 2nd process, as shown in drawing 17 (a), the 1st bias antiferromagnetism film 171 is formed and the cap layer 172 is further formed on it so that the free magnetic layer 54 top at the topmost part of the GMR element 55 may be covered. next, it is shown in drawing 17 (b) -- as -- the cap layer 172 top -- a mushroom -- the type resist 173 is formed, as the cap layer 172 is shaved off and it is shown in drawing 17 (c), on it, membrane formation formation of the 2nd bias antiferromagnetism film 174 of a right-and-left couple is carried out, and the antiferromagnetism film 175 which has the level difference from which thickness differs is formed, so that the front face of the 1st bias antiferromagnetism film 171 may be exposed to right and left

[0064] as the 3rd process, it is shown in drawing 18 -- as -- a mushroom -- using the type resist 173, on the 2nd bias antiferromagnetism film 174 of a right-and-left couple, non-magnetic materials, such as Cu, Cr, or Ta, are used, and membrane formation formation of the electrode lead layer 181 of a right-and-left couple is carried out

[0065] The process after it is the same as the form 2 of the above-mentioned operation.

[0066] In addition, it cannot be overemphasized like other examples of the 1st process of the form 2 of the above-mentioned operation that a laminating fixed magnetic layer or a laminating free magnetic layer may be formed.

[0067] moreover, like other examples of the 2nd process of the form 3 of the above-mentioned operation as other examples of the 2nd process it is shown in drawing 17 (b) -- as -- the cap layer 172 top -- a mushroom -- so that the type resist 173 may be formed and the front face of the 1st bias antiferromagnetism film 171 may be exposed to right and left In shaving off the cap layer 172 and carrying out membrane formation formation of the 2nd bias anti-******** using another equipment The upper surface of the 1st exposed bias antiferromagnetism film 171 is cleaned by methods, such as a pulley spatter by Ar etc., or efficient consumer response. After removing the oxide film of the front face of the 1st bias antiferromagnetism film 171, the remnants of a resist, a foreign matter, or dirt, membrane formation formation of the 2nd bias antiferromagnetism film 174 of a right-and-left couple is carried out on the 1st bias antiferromagnetism film 171. It is more desirable to form the antiferromagnetism film 175 which has the level difference from which thickness differs. On the 1st antiferromagnetism film with which the upper surface was cleaned, very good adhesion and a magnetic combination are stabilized, and are obtained between the 1st antiferromagnetism film and the 2nd antiferromagnetism film by carrying out membrane formation formation of the 2nd antiferromagnetism film, and the direction of the magnetization of a free magnetic layer which has the joint magnetic field by the big antiferromagnetism film of thickness and strong antiferromagnetism combination becomes what was stabilized very much.

[0068] Moreover, when the equipment which forms the 1st bias antiferromagnetism layer membrane 171 in the 2nd process differs from the equipment which forms the GMR element 55 in the 1st process Like other examples of the 2nd process of the form 3 of the above-mentioned operation as other examples of the 2nd process The upper surface of the free magnetic layer 54 is cleaned by methods, such as a pulley spatter by Ar etc., or efficient consumer response. It is made to be the same as that of the 2nd process shown in drawing 17 , after removing the oxide film of the front fac of the free magnetic layer 54, the remnants of a resist, a foreign matter, or dirt. the cleaned free magnetic layer 54 top -- a wrap -- like -- the 1st bias antiferromagnetism film 171 -- forming membranes -- further -- a it top -- th cap layer 172 -- forming membranes -- a it top -- a mushroom -- it is better to have formed the type resist 173 and to carry out m mbrane formation formation of the 2nd bias antiferromagnetism film 174 of a right-and-l ft couple There is no intervention of a for ign matter between the free magn tic layer 54 and the 1st bias antiferromagnetism film 171 by cleaning the upper surface of the fr e magnetic layer 54 at this time, and the joint magnetic field stabilized more can be acquired, without the joint magn tic field str ngth of a bias antiferromagnetism film and a free magn tic lay r falling, sinc very good adh sion and a magnetic combination are stabilized and are obtained.

[0069] moreover, th mushroom formed at the 2nd process as other xamples of the 3rd proc ss, as shown in drawing 19 , after deleting a type resist So that the exposed 2nd bias antiferromagnetism film 174 and cap layer 172 top may be covered A photoresist may be applied, the lectrode l ad layer membrane 191 may be shav d off by m thods, such as dry etching, and the electrode lead layer 192 of a right-and-left couple may be formed so that the lectrode lead layer membran 191 may be formed and a part of cap layer 172 may b expos d after that. Moreover, after shaving off an

electrode lead layer, it is also possible to choose the material of the cap layer 172 so that the bias antiferromagnetism film 171 may not be shaved.
[0070] moreover, the mushroom formed at the 2nd process as other examples of the 3rd process — after deleting a type resist, it is shown in drawing 20 -- as -- another mushroom on the cap layer 172 — the type resist 201 may be formed and the electrode lead layer 202 of a right-and-left couple may be formed
[0071] In addition, as for each heat treatment to the antiferromagnetism layer and bias antiferromagnetism film for adding the direction of magnetization in a predetermined direction to a fixed magnetic layer and a free magnetic layer, r spectively, it is desirable to carry out, after a cap layer is formed, and before patterning of a bias antiferromagnetism film and the GMR element is carried out to a predetermined configuration and they are shaved off. It cannot be overemphasized by the heat treatment conditions (a magnetic field, processing temperature, and processing time) to the antiferromagnetism layer for adding the direction of magnetization to a fixed magnetic layer here, and the heat treatment conditions to the bias antiferromagnetism film for adding the direction of magnetization to a free magnetic layer that the material of the bias antiferromagnetism film which touches the antiferromagnetism layer and free magnetic layer which touch a fixed magnetic layer, respectively must be chosen so that at least one condition items may differ.
[0072] According to the form 4 of this operation, as mentioned above by very strong antiferromagnetism combination of the free magnetic layer which is in contact with the big bias antiferromagnetism film of thickness like the form 2 of the above-mentioned above-mentioned operation, and the form 3 of operation The direction of magnetization of the free magnetic layer which is in contact with the small bias antiferromagnetism film of thickness It becomes a bird clapper that it is easy to be suitable towards the same magnetization as the free magnetic layer which is in contact with the big bias antiferromagnetism film of thickness. On the 1st antiferromagnetism film with which the direction of the magnetization stabilized very much was obtained, and the upper surface was cleaned, by carrying out membrane formation formation of the 2nd antiferromagnetism film between the 1st antiferromagnetism film and the 2nd antiferromagnetism film Very good adhesion and a magnetic combination are stabilized, and are obtained, and the direction of the magnetization of a free magnetic layer which has the joint magnetic field by the big antiferromagnetism film of thickness and strong antiferromagnetism combination becomes what was stabilized very much. Moreover, since time for a bias antiferromagnetism film to be exposed by preparing a cap layer on the 1st antiferromagnetism film by this manufacture method is sharply reducible, Property degradation of a bias antiferromagnetism film can be suppressed and the magnetoresistance-effect type thin film head of the outstanding reproducibility ability with high reproduction sensitivity with few Barkhausen noises can be produced.
[0073]
[Effect of the Invention] The joint magnetic field of the soft-magnetism film with which this invention is in contact with the antiferromagnetism film as mentioned above The property of carrying out abbreviation saturation if it will become large if the thickness of an antiferromagnetism film is large, and it becomes beyond a certain range is used. By preparing the bias antiferromagnetism film which has a level difference so that thickness may be small and thickness may become [except near the head truck] large on the free magnetic layer of a GMR element near the portion which constitutes a head truck The portion of the free magnetic layer which is in contact with the bias antiferromagnetism film of the big portion of thickness Carry out antiferromagnetism combination with a bias antiferromagnetism film, and it is combined by the very strong joint magnetic field. The free magnetic layer of the portion which the direction of the magnetization became what was stabilized very much, therefore is in contact with the bias antiferromagnetism film of the small portion of thickness also by the small joint magnetic field The direction of the magnetization which was easy to turn to in the same direction as the magnetization direction of the portion of the free magnetic layer which was stabilized and is in contact with the large bias antiferromagnetism film of thickness, and was stabilized is obtained. Moreover, since the antiferromagnetism joint magnetic field of the portion of the free magnetic layer which is in contact with the antiferromagnetism film of the small portion of thickness is small, The direction of magnetization becomes easy to change with the magnetic fields from a magnetic-recording medium, and the effect that reproducibility ability, like a Barkhausen noise is small and reproduction sensitivity is high can be improved is not concerned with reproduction gap length, but it is ******. Moreover, it has the effect that the magnetoresistance-effect type thin film magnetic head which has such outstanding reproducibility ability is producible.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The transverse-plane outline diagram of the thin film magnetic head showing the gestalt 1 of operation of this invention
[Drawing 2] Some transverse-plane outline diagrams of the thin film magnetic head showing other examples of the gestalt 1 of operation of this invention
[Drawing 3] The graph which shows the relation between the layer joint magnetic field strength added to the free magnetic layer for explaining the gestalt 1 of operation of this invention, and a reproduction output
[Drawing 4] Outline explanatory drawing showing some processes of the manufacturing process explaining the gestalt 2 of operation of this invention of the thin film magnetic head
[Drawing 5] Outline explanatory drawing showing the 1st process in the gestalt 2 of operation of this invention
[Drawing 6] Outline explanatory drawing showing the 2nd process in the gestalt 2 of operation of this invention
[Drawing 7] Outline explanatory drawing showing the 3rd process in the gestalt 2 of operation of this invention
[Drawing 8] Outline explanatory drawing showing the 4th process in the gestalt 2 of operation of this invention
[Drawing 9] Outline explanatory drawing showing other examples of the 1st process in the gestalt 2 of operation of this invention
[Drawing 10] Outline explanatory drawing showing other examples of the 3rd process in the gestalt 2 of operation of this invention
[Drawing 11] Outline explanatory drawing showing other examples of the 3rd process in the gestalt 2 of operation of this invention
[Drawing 12] Outline explanatory drawing showing the 2nd process in the gestalt 3 of operation of this invention
[Drawing 13] Outline explanatory drawing showing the 3rd process in the gestalt 3 of operation of this invention
[Drawing 14] Outline explanatory drawing showing the 4th process in the gestalt 3 of operation of this invention
[Drawing 15] Outline explanatory drawing showing other examples of the 3rd process in the gestalt 3 of operation of this invention
[Drawing 16] Outline explanatory drawing showing other examples of the 3rd process in the gestalt 3 of operation of this invention
[Drawing 17] Outline explanatory drawing showing the 2nd process in the gestalt 4 of operation of this invention
[Drawing 18] Outline explanatory drawing showing the 3rd process in the gestalt 4 of operation of this invention
[Drawing 19] Outline explanatory drawing showing other examples of the 3rd process in the gestalt 4 of operation of this invention
[Drawing 20] Outline explanatory drawing showing other examples of the 3rd process in the gestalt 4 of operation of this invention
[Drawing 21] The tropia schematic diagram showing the conventional thin film magnetic head
[Drawing 22] The transverse-plane outline diagram showing the conventional thin film magnetic head
[Description of Notations]
1 51,224 Antiferromagnetism layer
2 52,225 Fixed magnetic layer
3 53,226 Non-magnetic layer
4 54,227 Free magnetic layer
5, 55, 92, 94,213 Magnetoresistance-effect element (GMR element)
6 62,112,124 The 1st flat surface
7 63,113,125 The 2nd flat surface
8 64,114,126,175 Bias antiferromagnetism film
9, 72, 102, 115, 131, 152, 162, 181, 192, 202, 215 Electrode lead layer
10 81,141,172,228 Cap layer
40 Substrate
41,211 Lower shield layer
42,212 Lower gap insulating layer
61 Bias Antiferromagnetism Layer Membrane
71,111,151,191 Electrode lead layer membrane
91 Laminating Fixed Magnetic Layer
93 Laminating Free Magnetic Layer
101, 122, 161, 163, and 201 a mushroom — type resist
121 171 1st bias antiferromagnetism film
123 174 2nd bias antif rromagnetism film
214 Vertical Bias Layer
216 Up Gap Insulating Layer
217 Up Shield Layer
218 Magn tor sistanc -Effect Type Thin Film Magnetic H ad for R production
220 Induction-Type Thin Film Magnetic Head for Record
221 Record Gap Layer
222 Up Magnetic Pole
223 Coil Coil

229 Reproduction Head Gap Length
901 1st Fixed Magnetic Layer Film
902 1st Non-magnetic Layer Film
903 2nd Fixed Magnetic Layer Film
911 1st Free Magnetic Layer Film
912 2nd Free Magnetic Layer Film
913 N-th Free Magnetic Layer Film

[Translation done.]

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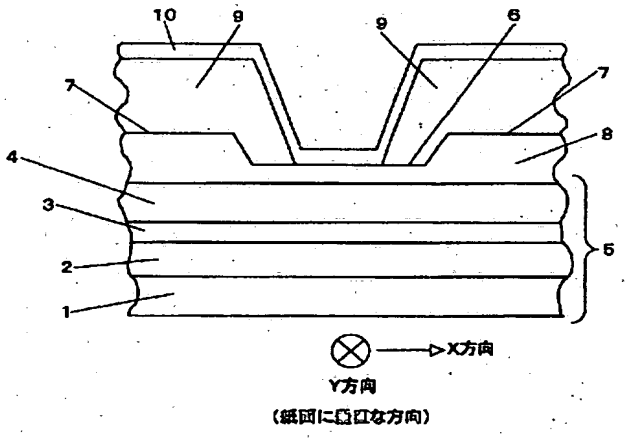
(54)【発明の名称】　薄膜磁気ヘッド及びその製造方法

(57)【要約】

【課題】　高記録密度化に伴う短波長の記録信号を再生するために狭ギャップレングス化された再生ヘッドにおいて、安定した縦バイアスを供給し、高感度で、且つ安定した再生性能を有する薄膜磁気ヘッド及びその製造方法を提供する。

【解決手段】　磁気抵抗効果素子の最上部に形成されたフリー磁性層の上に膜厚差による段差を有するバイアス反強磁性膜を成膜形成することによって、膜厚の大きな部分のバイアス反強磁性膜に接しているフリー磁性層の部分の結合磁界を非常に強くし、膜厚の小さい部分のバイアス反強磁性膜に接しているフリー磁性層の部分の結合磁界を小さくできるため、ギャップレングスに関わらずバルクハウゼンノイズが安定して抑えられ、且つ、再生感度を向上できる。



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【特許請求の範囲】

【請求項１】　下部シールド層と上部シールド層との間に絶縁材を介して磁気抵抗効果素子を有し、前記磁気抵抗効果素子に接して設けられた縦バイアス層と、信号電流を流すための電極リード層からなる磁気抵抗効果型薄膜磁気ヘッドにおいて、

反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、

膜厚差による段差のある第１の平面と第２の平面を有するバイアス反強磁性膜と、からなる構成を有することを特徴とする薄膜磁気ヘッド。

【請求項２】　膜厚の小さい前記第1の平面を構成する前記バイアス反強磁性膜の部分に接している前記フリー磁性層の部分の反強磁性結合による結合磁界が

８ｋＡ／ｍ　以下　（１０００ｅ　以下）

であることを特徴とする請求項1に記載の薄膜磁気ヘッド。

【請求項３】　下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、前記磁気抵抗効果素子の上を覆うように、バイアス反強磁性層膜を成膜した後、前記バイアス反強磁性層膜の一部を削除し、第１の平面を有する膜厚の小さい部分と第２の平面を有する膜厚の大きい部分とからなる段差のあるバイアス反強磁性膜を形成する第２の工程と、

前記バイアス反強磁性膜の上を覆うように、電極リード層膜を成膜し、前記バイアス反強磁性膜の第１の平面の少なくとも一部が露出するように、少なくとも電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程と、を有することを特徴とする薄膜磁気ヘッドの製造方法。

【請求項４】　請求項３の第３の工程において、前記バイアス反強磁性膜の第１の平面上に茸型レジストを形成して、前記バイアス反強磁性膜の上に左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項３に記載の薄膜磁気ヘッドの製造方法。

【請求項５】　請求項３の第２の工程及び第３の工程において、前記フリー磁性層の上を覆うように、バイアス反強磁性層膜を成膜する第２の工程と、

更に、その上を覆うように、電極リード層膜を成膜した後、前記バイアス反強磁性層膜の一部が削り取られて露出するように、前記電極リード層膜及び前記バイアス反強磁性層膜の夫々の一部を削除して、削除されて露出した前記バイアス反強磁性層膜の上面を第１の平面、成膜時の前記バイアス反強磁性層膜の上面を第２の平面とする膜厚差による段差を有するバイアス反強磁性膜及び前記バイアス反強磁性膜の第２の平面上に左右一対の電極リード層を形成する第３の工程と、を有することを特徴とする請求項３に記載の薄膜磁気ヘッドの製造方法。

【請求項６】　下部ギャップ絶縁層の上に、反強磁性

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層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、前記磁気抵抗効果素子を構成する前記フリー磁性層の上を覆うように、第１のバイアス反強磁性膜を成膜し、前記第１のバイアス反強磁性膜の上面に茸型レジストを形成して、左右一対の第２のバイアス反強磁性膜を成膜形成し、前記第１のバイアス反強磁性膜の露出している上面を第１の平面、前記第２のバイアス反強磁性膜の上面を第２の平面とし、且つ、前記第１の平面の部分の膜厚は前記第１のバイアス反強磁性膜の膜厚であり、前記第２の平面の部分の膜厚は前記第１のバイアス反強磁性膜の膜厚と前記第２のバイアス反強磁性膜の膜厚との和であり、それらの間に膜厚差を有する段差があるバイアス反強磁性膜を形成する第２の工程と、

前記第２のバイアス反強磁性膜の上に、左右一対の電極リード層を成膜形成する第３の工程と、を有することを特徴とする薄膜磁気ヘッドの製造方法。

【請求項７】　請求項６の第２の工程において、前記磁気抵抗効果素子を構成する前記フリー磁性層の上を覆うように、第１のバイアス反強磁性膜を成膜し、前記第１のバイアス反強磁性膜の上面に茸型レジストを形成して、前記第１のバイアス反強磁性膜の上面をクリーニングした後、左右一対の第２のバイアス反強磁性膜を成膜形成し、前記第１のバイアス反強磁性膜の露出している上面を第１の平面、前記第２のバイアス反強磁性膜の上面を第２の平面とし、前記第１の平面と前記第２の平面との間に膜厚差による段差があるバイアス反強磁性膜を形成する第２の工程を有することを特徴とする請求項６に記載の薄膜磁気ヘッドの製造方法。

【請求項８】　請求項６の第３の工程において、前記第２の工程にて形成したレジストを削除した後、前記第１のバイアス反強磁性膜の露出した部分及び左右一対の前記第２のバイアス反強磁性膜の上を覆うように、電極リード層膜を成膜し、前記第１のバイアス反強磁性膜の少なくとも一部が露出するように、少なくとも前記電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項６或いは請求項７のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項９】　請求項６の第３の工程において、前記第２の工程にて形成したレジストを削除した後、前記第１のバイアス反強磁性膜の第１の平面の上に、茸型レジストを形成して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項６或いは請求項７のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項１０】　段差を有する前記バイアス反強磁性膜の上に形成された左右一対の前記電極リード層及び前記バイアス反強磁性膜の第１の平面の露出した部分の上を覆うように、キャップ層を形成する第４の工程を有することを特徴とする請求項３～請求項９のいずれかに記載

の薄膜磁気ヘッドの製造方法。

【請求項１１】　下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、前記フリー磁性層の上を覆うように第１のバイアス反強磁性膜を成膜し、更に、その上を覆うようにキャップ層を成膜した後、前記キャップ層の上に茸型レジストを形成して、前記第１のバイアス反強磁性膜が露出するように、少なくとも前記キャップ層の一部を削り取り、その上に、左右一対の第２のバイアス反強磁性膜を成膜形成して、前記キャップ層に接した前記第１のバイアス反強磁性膜の上面を第１の平面、前記第２のバイアス反強磁性膜の上面を第２の平面とし、且つ、前記第１の平面の部分の膜厚は前記第１のバイアス反強磁性膜の膜厚であり、前記第２の平面の部分の膜厚は前記第１のバイアス反強磁性膜の膜厚と前記第２のバイアス反強磁性膜の膜厚との和であり、それらの間に膜厚差を有する段差があるバイアス反強磁性膜を形成する第２の工程と、

前記第２のバイアス反強磁性膜の上に、左右一対の電極リード層を成膜形成する第３の工程と、を有することを特徴とする薄膜磁気ヘッドの製造方法。

【請求項１２】　請求項１１の第３の工程において、前記第２の工程にて形成されたレジストを削除した後、前記キャップ層の上に茸型レジストを形成して、左右一対の電極リード層を成膜形成する第３の工程を有することを特徴とする請求項１１に記載の薄膜磁気ヘッドの製造方法。

【請求項１３】　請求項１１の第３の工程において、前記第２の工程にて形成されたレジストを削除した後、前記第２のバイアス反強磁性膜及び前記キャップ層の上を覆うように、電極リード層膜を成膜し、前記キャップ層の少なくとも一部が露出するように、少なくとも前記電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項１１或いは請求項１２のいずれかに記載の薄膜磁気ヘッドの製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、磁気ディスク装置（ＨＤＤ装置）等の磁気記録媒体に対して高密度の記録・再生を行う装置に適用され、特に、磁気抵抗効果素子のフリー磁性層に安定したバイアス磁界を与えて再生効率の高い磁気抵抗効果型薄膜磁気ヘッド及びその製造方法に関するものである。

【０００２】

【従来の技術】近年、磁気ディスク装置（ＨＤＤ装置）等の磁気記録媒体に対する記録・再生において、処理速度の向上と記録容量の大容量化の必要性が増してきており、高記録密度化への取り組みが強化されつつある。

【０００３】以下、従来の薄膜磁気ヘッドについて図面

を用いて説明する。

【０００４】図２１及び図２２は、従来の薄膜磁気ヘッドを示す図であり、図２１は斜視概略図、図２２は薄膜磁気ヘッドの正面概略模式図である。

【０００５】例えば、磁気ディスク装置における信号の磁気記録媒体への記録再生に用いられる薄膜磁気ヘッドは、図２１に示すような所謂ＭＲ（ＧＭＲ）インダクティブ複合ヘッドと呼ばれているものが多い。

【０００６】図２１において、パーマロイ、Ｃｏ系アモルファス磁性膜或いはＦｅ系合金磁性膜等の軟磁性材料で成膜された下部シールド層２１１の上にAl_2O_3、ＡｌＮ或いはSiO_2等の非磁性絶縁材料を用いて下部ギャップ絶縁層２１２が成膜され、更にその上面に磁気抵抗効果素子（ＭＲ素子或いはＧＭＲ素子。以下、ＧＭＲ素子と言う）２１３が積層成膜形成され、ＧＭＲ素子２１３の左右両側端部にＣｏＰｔ合金等の材料で縦バイアス層２１４が成膜される。更に、ＧＭＲ素子２１３の上面とその両側面とのなす交線である稜線に接し、縦バイアス層２１４の上面に、Ｃｕ、Ｃｒ或いはＴａ等の材料を用いて左右一対の電極リード層２１５が成膜される。ここで、縦バイアス層２１４の上面及びＧＭＲ素子２１３の一部の上面にかかるようにして、電極リード層２０５を成膜しても良い。次に、電極リード層２１５とＧＭＲ素子２１３の露出した部分の上に、下部ギャップ絶縁層２１２と同様の非磁性絶縁材料を用いて上部ギャップ絶縁層２１６を成膜する。更に、上部ギャップ絶縁層２１６の上に、下部シールド層２１１と同じような軟磁性材料を用いて上部シールド層２１７を成膜形成し、再生用磁気抵抗効果型薄膜磁気ヘッド部２１８を構成する。

【０００７】次に、上部シールド層２１７の上面に下部ギャップ絶縁層２１２と同様の非磁性絶縁材料を用いて記録ギャップ層２２１を成膜し、更に記録ギャップ層２２１を介して上部シールド層２１７に対向し、且つ、他の部分で上部シールド層２１７に接している上部磁極２２２を軟磁性材料を用いて成膜形成し、記録ギャップ層２２１を介して上部シールド層２１７と上部磁極２２２が対向している部分と上部磁極２２２が上部シールド層２１７に接している部分との間で、上部シールド層２１７と上部磁極２２２から絶縁材（図示せず）を介して絶縁された巻線コイル２２３が設けられて、記録用の誘導型薄膜磁気ヘッド部２２０を構成する。ここで、上部シールド層２１７は再生用磁気抵抗効果型薄膜磁気ヘッド部２１８のシールド機能と記録用誘導型薄膜磁気ヘッド部２２０の下部磁極機能とを兼ね備えた機能を有している。

【０００８】巻線コイル２２３に記録電流が供給されることにより、記録用誘導型薄膜磁気ヘッド部２２０の上部磁極２２２と上部シールド層２１７に記録磁界が発生し、記録ギャップ層２２１を介して対向する上部磁極２２２と上部シールド層２１７との間に漏洩磁束が発生

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し、磁気記録媒体に記録信号を記録する。また、信号が記録された磁気記録媒体に記録された信号の磁界を再生用磁気抵抗効果型薄膜磁気ヘッド部２１８で再生し、ＧＭＲ素子２１３による抵抗変化に応じた再生信号を電極リード層２１５の端子から検出する。

【０００９】図２２に、薄膜磁気ヘッドの再生ヘッド部における磁気抵抗効果素子近傍の正面概略模式図を示すように、下部シールド層２１１の上面に成膜された下部ギャップ絶縁層２１２の上に、ＦｅＭｎ系合金膜、ＰｔＭｎ系合金膜等の材料である反強磁性層２２４、ＦｅＮｉ系合金膜、パーマロイ、Ｃｏ、ＦｅＣｏ合金膜等を材料とする固定磁性層２２５、Ｃｕ等を材料とする非磁性層２２６、固定磁性層２２５と同様の材料とするフリー磁性層２２７及びＴａ等を材料とするキャップ層２２８が順次積層成膜され、イオンミリング等のエッチング工程で左右両側端部が傾斜した面を持つように削り取られてＧＭＲ素子２１３が形成されている。ＧＭＲ素子２１３の左右両側端面に接して、左右一対の縦バイアス層２１４が形成され、その上に左右一対の電極リード層２１５が形成されている。更に、それらの上に、上部ギャップ絶縁層２１６が成膜され、更にその上に、上部シールド層２１７が形成され、再生用磁気抵抗効果型薄膜ヘッドを構成している。近年、高記録密度化に対応した短波長の記録信号を再生するために、再生ヘッドギャップレングス２２９が益々小さくなってきている。

【００１０】

【発明が解決しようとする課題】しかしながら上記の従来の構成の薄膜磁気ヘッドの再生ヘッド部において、磁気記録媒体に短波長で記録された信号を再生するためには、再生ヘッドギャップレングスを小さくする必要がある。再生ヘッドギャップレングスは下部シールド層の上面から上部シールド層の下面までの距離即ち下部ギャップ絶縁層、ＧＭＲ素子及び上部ギャップ絶縁層の夫々の膜厚の和であり、この距離を小さくすることはＧＭＲ素子の両側にある左右一対の縦バイアス層が下部シールド層或いは上部シールド層に接近することになり、縦バイアス層の磁界が下部シールド層或いは上部シールド層に逃げ易くなり、ＧＭＲ素子の縦バイアス層近傍のフリー磁性層にはバイアス磁界がかかるが、フリー磁性層の中央部分（トラック幅方向の中央部分）ではバイアス磁界が弱まって、フリー磁性層の磁化の方向が不安定になり、ノイズが増加し、安定した再生信号が得られず、安定した再生信号を得るために、縦バイアス磁界を強くする対策を行うと、フリー磁性層の磁化は安定し、バルクハウゼンノイズは抑えられるが、感度が低下し、固定磁性層の磁化の方向も大きく傾き、対称性が悪化するという課題があった。

【００１１】本発明は、上記の課題を解決し、ＧＭＲ素子のフリー磁性層の上に形成された膜厚の異なる段差を有する反強磁性膜と反強磁性的に結合した結合磁界によって、フリー磁性層に安定した縦バイアスを加え、フリー磁性層の磁化の方向を安定させ、バルクハウゼンノイズの発生を抑え、再生性能の良好な磁気抵抗効果型薄膜磁気ヘッド及びその製造方法を提供することを目的とする。

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【００１２】

【課題を解決するための手段】この目的を達成するために本発明の薄膜磁気ヘッドは、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、膜厚差による段差のある第１の平面と第２の平面を有するバイアス反強磁性膜とからなるようにした構成を有している。また、本発明の薄膜磁気ヘッドは、膜厚の小さい第1の平面を構成するバイアス反強磁性膜の部分に接しているフリー磁性層の部分の反強磁性結合による結合磁界が　８ｋＡ／ｍ以下（１００Ｏｅ　以下）　であるようにした構成を有している。

【００１３】この構成によって、非常に強く磁化方向を固定したい部分(フリー磁性層のトラック幅部分以外の部分)に強いバイアス磁界をかけ、一方、バルクハウゼンノイズを抑えるためにバイアス磁界はかけなければならないが、強い磁界をかけると再生感度が低下するためあまり強い磁界をかけたくない部分(フリー磁性層のトラック幅部分)に最適なバイアス磁界をかけることが、それぞれの部分の反強磁性膜の膜厚によって容易に制御することが可能となる。つまり、膜厚の大きな第２の平面の部分の反強磁性膜に接しているフリー磁性層には、強い反強磁性結合による結合磁界が得られて、その磁化の方向は非常に安定したものとなり、そのため、膜厚の小さい第１の平面の部分の反強磁性膜に接しているフリー磁性層の部分の反強磁性結合による結合磁界が小さくても、安定して膜厚の大きな第２の平面の部分の反強磁性膜に接しているフリー磁性層の磁化の方向と同じ磁化の方向に向き易くなり、また、膜厚の小さい第１の平面の部分の反強磁性膜に接しているフリー磁性層の部分の反強磁性結合磁界は小さいため、外部磁界即ち磁気記録媒体からの磁界によって、その磁化の方向が変化し易くなり、バルクハウゼンノイズの発生が少なく、再生感度が高く、再生性能を安定化させることができる。また、反強磁性膜との結合磁界によってバイアス磁界をかけるため、ギャップレングスに関わらず同様の効果を有し、かつ、このバイアス磁界が固定磁性層に与える影響はなく、それによる固定磁性層の磁化の傾きも生じないため、出力波形の対称性の劣化が抑えられる。また、第一の平面の部分の反強磁性膜の膜厚を最適に選ぶことによって、反強磁性膜とフリー磁性層との結合磁界を８ｋＡ／ｍ以下の強さに安定して与えることができ、再生性能の向上を図ることができる。

【００１４】また、本発明の薄膜磁気ヘッドの製造方法は、下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁

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気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子の上を覆うように、バイアス反強磁性層膜を成膜した後、バイアス反強磁性層膜の一部を削除し、第１の平面を有する膜厚の小さい部分と第２の平面を有する膜厚の大きい部分とからなる段差のあるバイアス反強磁性膜を形成する第２の工程と、バイアス反強磁性膜の上を覆うように、電極リード層膜を成膜し、バイアス反強磁性膜の第１の平面の少なくとも一部が露出するように、少なくとも電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程とを有している。また、本発明の薄膜磁気ヘッドの製造方法は、バイアス反強磁性膜の第１の平面上に茸型レジストを形成して、バイアス反強磁性膜の上に左右一対の電極リード層を形成する第３の工程を有している。また、本発明の薄膜磁気ヘッドの製造方法は、フリー磁性層の上を覆うように、バイアス反強磁性層膜を成膜する第２の工程と、更に、その上を覆うように、電極リード層膜を成膜した後、バイアス反強磁性層膜の一部が削り取られて露出するように、電極リード層膜及びバイアス反強磁性層膜の夫々の一部を削除して、削除されて露出したバイアス反強磁性層膜の上面を第１の平面、成膜時のバイアス反強磁性層膜の上面を第２の平面とする膜厚差による段差を有するバイアス反強磁性膜及びバイアス反強磁性膜の第２の平面上に左右一対の電極リード層を形成する第３の工程とを有している。また、本発明の薄膜磁気ヘッドの製造方法は、下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子を構成するフリー磁性層の上を覆うように、第１のバイアス反強磁性膜を成膜し、第１のバイアス反強磁性膜の上面に茸型レジストを形成して、左右一対の第２のバイアス反強磁性膜を成膜形成し、第１のバイアス反強磁性膜の露出している上面を第１の平面、第２のバイアス反強磁性膜の上面を第２の平面とし、且つ、第１の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚であり、第２の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚と第２のバイアス反強磁性膜の膜厚との和であり、それらの間に膜厚差を有する段差があるバイアス反強磁性膜を形成する第２の工程と、第２のバイアス反強磁性膜の上に、左右一対の電極リード層を成膜形成する第３の工程とを有している。また、本発明の薄膜磁気ヘッドの製造方法は、磁気抵抗効果素子を構成する前記フリー磁性層の上を覆うように、第１のバイアス反強磁性膜を成膜し、第１のバイアス反強磁性膜の上面に茸型レジストを形成して、第１のバイアス反強磁性膜の上面をクリーニングした後、左右一対の第２のバイアス反強磁性膜を成膜形成し、第１のバイアス反強磁性膜の露出している上面を第１の平面、第２のバイアス反強磁性膜の上面を第２の平面とし、第１の平面と第２の平面との間に膜厚差による段差があるバイアス反強磁性膜を形成

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する第２の工程を有している。また、本発明の薄膜磁気ヘッドの製造方法は、前記第２の工程にて形成したレジストを削除した後、第１のバイアス反強磁性膜の露出した部分及び左右一対の第２のバイアス反強磁性膜の上を覆うように、電極リード層膜を成膜し、第１のバイアス反強磁性膜の少なくとも一部が露出するように、少なくとも電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有している。また、本発明の薄膜磁気ヘッドの製造方法は、第２の工程にて形成したレジストを削除した後、第１のバイアス反強磁性膜の第１の平面の上に、茸型レジストを形成して、左右一対の電極リード層を形成する第３の工程を有している。また、本発明の薄膜磁気ヘッドの製造方法は、段差を有するバイアス反強磁性膜の上に形成された左右一対の電極リード層及びバイアス反強磁性膜の第１の平面の露出した部分の上を覆うように、キャップ層を形成する第４の工程を有している。また、本発明の薄膜磁気ヘッドの製造方法は、下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、フリー磁性層の上を覆うように第１のバイアス反強磁性膜を成膜し、更に、その上を覆うようにキャップ層を成膜した後、キャップ層の上に茸型レジストを形成して、第１のバイアス反強磁性膜が露出するように、少なくともキャップ層の一部を削り取り、その上に、左右一対の第２のバイアス反強磁性膜を成膜形成して、キャップ層に接した第１のバイアス反強磁性膜の上面を第１の平面、第２のバイアス反強磁性膜の上面を第２の平面とし、且つ、第１の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚であり、第２の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚と第２のバイアス反強磁性膜の膜厚との和であり、それらの間に膜厚差を有する段差があるバイアス反強磁性膜を形成する第２の工程と、第２のバイアス反強磁性膜の上に、左右一対の電極リード層を成膜形成する第３の工程とを有している。また、本発明の薄膜磁気ヘッドの製造方法は、第２の工程にて形成されたレジストを削除した後、キャップ層の上に茸型レジストを形成して、左右一対の電極リード層を成膜形成する第３の工程を有している。また、本発明の薄膜磁気ヘッドの製造方法は、第２の工程にて形成されたレジストを削除した後、第２のバイアス反強磁性膜及びキャップ層の上を覆うように、電極リード層膜を成膜し、キャップ層の少なくとも一部が露出するように、少なくとも電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有している。

【００１５】この方法によって、膜厚差による段差を有する反強磁性膜をフリー磁性層の上に形成することにより、非常に強く磁化方向を固定したい部分（フリー磁性層のトラック幅部分以外の部分）に強いバイアス磁界をかけ、一方、バルクハウゼンノイズを抑えるためにバイ

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アス磁界はかけなければならないが、強い磁界をかけると再生感度が低下するためあまり強い磁界をかけたくない部分（フリー磁性層のトラック幅方向中央部）に最適なバイアス磁界をかけることが、それぞれの部分の反強磁性膜の膜厚によって容易に制御することが可能な磁気抵抗効果型薄膜磁気ヘッドを作製することができる。つまり、左右の膜厚の大きな部分に接しているフリー磁性層は非常に強い反強磁性結合による結合磁界で結合され、一方ヘッドトラック部近傍においては、フリー磁性層は膜厚の小さい反強磁性膜に接しており、比較的小さな反強磁性結合磁界によって結合されるが、その磁化の方向は、膜厚の大きな反強磁性膜と強い反強磁性結合による結合磁界を有しているフリー磁性層の磁化の方向と同じ方向に向くことになり、非常に安定した磁化の方向が得られ、ノイズの少ない、再生感度の高い、高再生性能の磁気抵抗効果型薄膜ヘッドを作製することができる。更に、上面がクリーニングされた第１の反強磁性膜の上に、第２の反強磁性膜が成膜形成されるため、第１の反強磁性膜と第２の反強磁性膜の間で、非常に良好な密着性および磁気的な結合が安定して得られ、フリー磁性層の磁化の方向が非常に安定した磁気抵抗効果型薄膜磁気ヘッドを作製することができる。また、キャップ層を形成することにより、反強磁性膜上面の酸化が防止され、耐食性も向上し、それらによる特性劣化が少ない、再生性能の優れた磁気抵抗効果型薄膜磁気ヘッドを作製することができる。

【００１６】

【発明の実施の形態】本発明の請求項１に記載の発明は、下部シールド層と上部シールド層との間に絶縁材を介して磁気抵抗効果素子を有し、前記磁気抵抗効果素子に接して設けられた縦バイアス層と、信号電流を流すための電極リード層からなる磁気抵抗効果型薄膜磁気ヘッドにおいて、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、膜厚差による段差のある第１の平面と第２の平面を有するバイアス反強磁性膜とからなる構成を有することを特徴としたものであり、また、本発明の請求項２に記載の発明は、膜厚の小さい第1の平面を構成するバイアス反強磁性膜の部分に接しているフリー磁性層の部分の反強磁性結合による結合磁界が　８ｋＡ／ｍ　以下　（１０００ｅ以下）　であることを特徴としたものであり、非常に強く磁化方向を固定したい部分（フリー磁性層のトラック幅部分以外の部分）に強いバイアス磁界をかけ、一方、バルクハウゼンノイズを抑えるためにバイアス磁界はかけなければならないが、強い磁界をかけると再生感度が低下するためあまり強い磁界をかけたくない部分（フリー磁性層のトラック幅方向中央部）に最適なバイアス磁界をかけることが、それぞれの部分の反強磁性膜の膜厚によって容易に制御することが可能となる。つまり、膜厚の大きな第２の平面の部分の反強磁性膜に接しているフリー磁性層には、強い反強磁性結合による結合磁界が得られて、その磁化の方向は非常に安定したものとなり、そのため、膜厚の小さい第１の平面の部分の反強磁性膜に接しているフリー磁性層の部分の反強磁性結合による結合磁界が小さくても、安定して膜厚の大きな第２の平面の部分の反強磁性膜に接しているフリー磁性層の磁化の方向と同じ磁化の方向に向き易くなり、また、膜厚の小さい第１の平面の部分の反強磁性膜に接しているフリー磁性層の部分の反強磁性結合磁界は小さいため、外部磁界即ち磁気記録媒体からの磁界によって、その磁化の方向が変化し易くなり、バルクハウゼンノイズの発生が少なく、再生感度が高く、再生性能を安定化させることができる。また、反強磁性膜との結合磁界によってバイアス磁界をかけるため、ギャップレングスに関わらず同様の効果を有し、かつ、このバイアス磁界が固定磁性層に与える影響はなく、それによる固定磁性層の磁化の傾きも生じないため、出力波形の対称性の劣化が抑えられる。また、第一の平面の部分の反強磁性膜の膜厚を最適に選ぶことによって、反強磁性膜とフリー磁性層との結合磁界を８ｋＡ／ｍ以下の強さに安定して与えることができ、再生性能の向上を図ることができるという作用を有している。

【００１７】また、本発明の請求項３に記載の発明は、下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子の上を覆うように、バイアス反強磁性層膜を成膜した後、バイアス反強磁性層膜の一部を削除し、第１の平面を有する膜厚の小さい部分と第２の平面を有する膜厚の大きい部分とからなる段差のあるバイアス反強磁性膜を形成する第２の工程と、バイアス反強磁性膜の上を覆うように、電極リード層膜を成膜し、バイアス反強磁性膜の第１の平面の少なくとも一部が露出するように、少なくとも電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項４に記載の発明は、請求項３の第３の工程において、バイアス反強磁性膜の第１の平面上に茸型レジストを形成して、バイアス反強磁性膜の上に左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項５に記載の発明は、請求項３の第２の工程及び第３の工程において、フリー磁性層の上を覆うように、バイアス反強磁性層膜を成膜する第２の工程と、更に、その上を覆うように、電極リード層膜を成膜した後、バイアス反強磁性層膜の一部が削り取られて露出するように、電極リード層膜及びバイアス反強磁性層膜の夫々の一部を削除して、削除されて露出したバイアス反強磁性層膜の上面を第１の平面、成膜時のバイアス反強磁性層膜の上面を第２の平面とする膜厚差による段差を有するバイアス反強磁性膜及びバイアス反強磁性膜

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の第２の平面上に左右一対の電極リード層を形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項６に記載の発明は、下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子を構成するフリー磁性層の上を覆うように、第１のバイアス反強磁性膜を成膜し、第１のバイアス反強磁性膜の上面に茸型レジストを形成して、左右一対の第２のバイアス反強磁性膜を成膜形成し、第１のバイアス反強磁性膜の露出している上面を第１の平面、第２のバイアス反強磁性膜の上面を第２の平面とし、且つ、第１の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚であり、第２の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚と第２のバイアス反強磁性膜の膜厚との和であり、それらの間に膜厚差を有する段差があるバイアス反強磁性膜を形成する第２の工程と、第２のバイアス反強磁性膜の上に、左右一対の電極リード層を成膜形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項８に記載の発明は、請求項６の第３の工程において、第２の工程にて形成したレジストを削除した後、第１のバイアス反強磁性膜の露出した部分及び左右一対の第２のバイアス反強磁性膜の上を覆うように、電極リード層膜を成膜し、第１のバイアス反強磁性膜の少なくとも一部が露出するように、少なくとも電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項９に記載の発明は、請求項６の第３の工程において、第２の工程にて形成したレジストを削除した後、第１のバイアス反強磁性膜の第１の平面の上に、茸型レジストを形成して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、非常に強く磁化方向を固定したい部分（フリー磁性層のトラック幅部分以外の部分）に強いバイアス磁界をかけ、一方、バルクハウゼンノイズを抑えるためにバイアス磁界はかけなければならないが、強い磁界をかけると再生感度が低下するためあまり強い磁界をかけたくない部分（フリー磁性層のトラック幅方向中央部）に最適なバイアス磁界をかけることが、それぞれの部分の反強磁性膜の膜厚によって容易に制御することが可能な磁気抵抗効果型薄膜磁気ヘッドを作製することができる。つまり、膜厚差による段差を有する反強磁性膜をフリー磁性層の上に形成することによって、左右の膜厚の大きな部分に接しているフリー磁性層は非常に強い反強磁性結合による結合磁界で結合され、一方ヘッドトラック部近傍においてはフリー磁性層は膜厚の小さい反強磁性膜に接しており、比較的小さな反強磁性結合磁界によって結合されるが、その磁化の方向は、膜厚の大きな反強磁性膜と強い反強磁性結合による結合磁界を有しているフリー磁性層の磁化の方向と同じ方向に向くことになり、非常に安定した磁化の方向が得られ、ノイズの少ない、再生感度の高い、高再生性能の磁気抵抗効果型薄膜ヘッドを作製することができるという作用を有している。

【００１８】また、本発明の請求項７に記載の発明は、請求項６の第２の工程において、磁気抵抗効果素子を構成するフリー磁性層の上を覆うように、第１のバイアス反強磁性膜を成膜し、第１のバイアス反強磁性膜の上面に茸型レジストを形成して、第１のバイアス反強磁性膜の上面をクリーニングした後、左右一対の第２のバイアス反強磁性膜を成膜形成し、第１のバイアス反強磁性膜の露出している上面を第１の平面、第２のバイアス反強磁性膜の上面を第２の平面とし、第１の平面と第２の平面との間に膜厚差による段差があるバイアス反強磁性膜を形成する第２の工程を有することを特徴としたものであり、膜厚差による段差を有する反強磁性膜をフリー磁性層の上に形成することによって、フリー磁性層には非常に安定した磁化の方向が得られることになり、更に、上面がクリーニングされた第１の反強磁性膜の上に、第２の反強磁性膜が成膜形成されるため、第１の反強磁性膜と第２の反強磁性膜の間で、非常に良好な密着性および磁気的な結合が安定して得られ、フリー磁性層の磁化の方向が非常に安定したものとなり、ノイズの少ない、再生感度の高い、高再生性能の磁気抵抗効果型薄膜ヘッドを作製することができるという作用を有している。

【００１９】また、本発明の請求項１０に記載の発明は、段差を有するバイアス反強磁性膜の上に形成された左右一対の電極リード層及びバイアス反強磁性膜の第１の平面の露出した部分の上を覆うように、キャップ層を形成する第４の工程を有することを特徴としたものであり、また、本発明の請求項１１に記載の発明は、下部ギャップ絶縁層の上に、反強磁性層、固定磁性層、非磁性層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、フリー磁性層の上を覆うように第１のバイアス反強磁性膜を成膜し、更に、その上を覆うようにキャップ層を成膜した後、キャップ層の上に茸型レジストを形成して、第１のバイアス反強磁性膜が露出するように、少なくともキャップ層の一部を削り取り、その上に、左右一対の第２のバイアス反強磁性膜を成膜形成して、キャップ層に接した第１のバイアス反強磁性膜の上面を第１の平面、第２のバイアス反強磁性膜の上面を第２の平面とし、且つ、第１の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚であり、第２の平面の部分の膜厚は第１のバイアス反強磁性膜の膜厚と第２のバイアス反強磁性膜の膜厚との和であり、それらの間に膜厚差を有する段差があるバイアス反強磁性膜を形成する第２の工程と、第２のバイアス反強磁性膜の上に、左右一対の電極リード層を成膜形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項１２に記載の発明は、請求項１１の第３の工程において、第２の工程にて形成されたレジストを削除

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した後、キャップ層の上に茸型レジストを形成して、左右一対の電極リード層を成膜形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項１３に記載の発明は、請求項１１の第３の工程において、第２の工程にて形成されたレジストを削除した後、第２のバイアス反強磁性膜及びキャップ層の上を覆うように、電極リード層膜を成膜し、キャップ層の少なくとも一部が露出するように、少なくとも電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、膜厚差による段差を有する反強磁性膜をフリー磁性層の上に形成することによって、フリー磁性層には非常に安定した磁化の方向が得られることになり、更に、少なくともバイアス反強磁性膜の露出している部分の上に、キャップ層を成膜することによって、バイアス反強磁性膜の露出した部分の酸化を防止し、耐食性を向上させることができ、それらによる特性劣化が少なく、ノイズの少ない、再生感度の高い、高再生性能の磁気抵抗効果型薄膜ヘッドを作製することができるという作用を有している。

【００２０】以下、本発明の実施の形態について、図面を用いて説明する。

【００２１】（実施の形態１）図１及び図２は、本発明の実施の形態１の概要を示す概略説明図で、図１は磁気記録媒体に対向するヘッド摺動面側から見た正面概略模式図、図２は磁気記録媒体に対向するヘッド摺動面側から見た薄膜磁気ヘッドの一部の正面概略模式図である。

【００２２】図１において、パーマロイ、Ｃｏ系アモルファス磁性膜或いはＦｅ系微粒子磁性膜等の軟磁性材料を素材とする下部シールド層（図示せず）の上に成膜されたＡｌ$_2$Ｏ$_3$、ＡｌＮ或いはＳｉＯ$_2$等の非磁性絶縁材料を用いた下部ギャップ絶縁層（図示せず）の上に、ＩｒＭｎ、αＦｅ$_2$Ｏ$_4$、ＮｉＯ、ＦｅＭｎ系合金膜、ＰｔＭｎ系合金膜等の材料である反強磁性層１、ＮｉＦｅ系合金膜、Ｃｏ、ＣｏＦｅ合金膜等を材料とする固定磁性層２、Ｃｕ等を材料とする非磁性層３及び固定磁性層２と同様の強磁性材料を材料とするフリー磁性層４で構成された磁気抵抗効果素子５（ＭＲ素子或いはＧＭＲ素子。以下、ＧＭＲ素子と言う）が構成されている。更に、ＧＭＲ素子５を構成する最上部にあるフリー磁性層４の上面に、膜厚が異なることによって第１の平面６及び第２の平面７のある段差を有し、且つ、反強磁性層１とは異種の反強磁性材料（場合によっては、酸化金属膜を用いない方が良い）を用いてバイアス反強磁性膜８が形成されている。更に、バイアス反強磁性膜８の上に、左右一対の電極リード層９が形成されている。

【００２３】尚、左右一対の電極リード層９及びバイアス反強磁性膜８の露出している部分の上に、Ｔａ等の非磁性材料を材料としてキャップ層１０を成膜し、バイアス反強磁性膜８の露出した部分の酸化を防止し、耐食性を向上させるのが好ましい。

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【００２４】固定磁性層２或いはフリー磁性層４の夫々に磁化の方向を付加する反強磁性層１或いはバイアス反強磁性膜８への夫々の熱処理（アニール処理）は、キャップ層１０が形成された後、且つキャップ層１０、電極リード層９及びバイアス反強磁性膜８が所定の形状にパターニングされて削り取られる前に、実施するのが良い。また、固定磁性層２に磁化の方向を設定するための反強磁性層１の熱処理条件とフリー磁性層に磁化の方向を付加するためのバイアス反強磁性膜８の熱処理条件とは、磁界の強さ、熱処理温度及び熱処理時間の少なくとも１つの条件が異なるように、反強磁性層１及びバイアス反強磁性膜８の夫々の材料を選定しなければならない。

【００２５】固定磁性層２は、反強磁性層１と強く反強磁性結合し、その結合磁界によって、その磁化の方向がＹ方向（紙面に直角の方向）に強く固定されている。他方、フリー磁性層４は、その上面にある膜厚差による段差を有するバイアス反強磁性膜８と反強磁性結合による結合磁界によって結合され、その磁化の方向がＸ方向（トラック幅方向）になるように磁化されているが、バイアス反強磁性膜８の膜厚によってその反強磁性結合による結合磁界の強さが異なることになり、膜厚の小さい第１の平面６の部分のバイアス反強磁性膜８に接しているフリー磁性層４の部分と、膜厚の大きい第２の平面７の部分のバイアス反強磁性膜８に接しているフリー磁性層４の部分では、その結合磁界の強さに差が生ずる。一般的に、膜厚が大きくなるにしたがって、その結合磁界も大きくなり、或る範囲以上になれば飽和するという特性を有し、その変化特性はバイアス反強磁性膜８の材料により異なる。

【００２６】図３はフリー磁性層にかかる結合磁界の強さと再生出力の関係をシミュレーションした図であり、フリー磁性層に付加された磁界の強さが非常に強い場合に比較して小さい時の方が再生出力は非常に高くなることが分かる。特に、８ｋＡ／ｍ以下（１０００ｅ以下）で急激に出力が向上している。

【００２７】従って、膜厚の小さい第1の平面６の部分のバイアス反強磁性膜８に接しているフリー磁性層４の部分において、バイアス反強磁性膜の第1の平面の部分の膜厚及びフリー磁性層に磁化の方向を与える熱処理条件（磁界の強さ、熱処理温度及び熱処理時間）を適当に設定し、バイアス反強磁性膜と第1の平面の部分のフリー磁性層との反強磁性結合による結合磁界が、８ｋＡ／ｍ以下（１０００ｅ以下）になるようにすることによって、高い再生出力を得ることができる。

【００２８】また、ＧＭＲ素子５を構成する固定磁性層２が、図２（ａ）に示すように、反強磁性層１の上に、第１の固定磁性層膜２１、非磁性層膜２２、第２の固定磁性層膜２３が積層成膜された構成を有している積層固定磁性層２４であっても良い。この時、第１の固定磁性

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層膜２１及び第２の固定磁性層膜２３の間に介在する非磁性層膜２２の膜厚によって、その非磁性層膜２２を介して対向する第１の固定磁性層膜２１及び第２の固定磁性層膜２３の磁化の方向が夫々同じ方向になったり、或いはお互いに逆の方向になったりする。

【００２９】また、ＧＭＲ素子５を構成するフリー磁性層４が、図２（ｂ）に示すように、フリー磁性層４と同様の材料を用いて、第１のフリー磁性層膜２５、第２のフリー磁性層膜２６、……、第ｎのフリー磁性層膜２７と順次積層成膜され、且つ、隣り合うフリー磁性層膜の材料はお互いに異種の材料を用いて成膜されている積層フリー磁性層２８でも良いのは言うまでもない。

【００３０】尚、本実施の形態１において、磁気抵抗効果素子を構成する非磁性層としてＣｕ等の非磁性導電材を用いた所謂ＧＭＲ素子について説明をしてきたが、非磁性層としてAl_2O_3等の非磁性絶縁材を用いた所謂ＴＭＲ素子に対しても電極リード層等の構成を変えて本発明を適用することができるのは言うまでもないことである。

【００３１】以上のように本実施の形態１によれば、非常に強く磁化方向を固定したい部分（フリー磁性層のトラック幅部分以外の部分）に強いバイアス磁界をかけ、一方、バルクハウゼンノイズを抑えるためにバイアス磁界はかけなければならないが、強い磁界をかけると再生感度が低下するためあまり強い磁界をかけたくない部分（フリー磁性層のトラック幅部分）に最適なバイアス磁界をかけることが、それぞれの部分の反強磁性膜の膜厚によって容易に制御することが可能となる。つまり、膜厚の大きな第２の平面の部分の反強磁性膜に接しているフリー磁性層には、強い反強磁性結合による結合磁界が得られて、その磁化の方向は非常に安定したものとなり、そのため、膜厚の小さい第１の平面の部分の反強磁性膜に接しているフリー磁性層の部分の反強磁性結合による結合磁界が小さくても、安定して膜厚の大きな第２の平面の部分の反強磁性膜に接しているフリー磁性層の磁化の方向と同じ磁化の方向に向き易くなり、また、膜厚の小さい第１の平面の部分の反強磁性膜に接しているフリー磁性層の部分の反強磁性結合磁界は小さいため、外部磁界即ち磁気記録媒体からの磁界によって、その磁化の方向が変化し易くなり、バルクハウゼンノイズの発生が少なく、再生感度が高く、再生性能を安定化させることができる。また、バイアス反強磁性膜との結合磁界によってバイアス磁界をかけるため、ギャップレングスに関わらず同様の効果を有し、かつ、このバイアス磁界が固定磁性層に与える影響はなく、それによる固定磁性層の磁化の傾きも生じないため、出力波形の対称性の劣化が抑えられる。また、第一の平面の部分の反強磁性膜の膜厚を最適に選ぶことによって、反強磁性膜とフリー磁性層との結合磁界を８ｋＡ／ｍ以下の強さに安定して与えることができ、再生性能の向上を図ることができる。

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【００３２】また、積層固定磁性層にすることによって、反強磁性層との結合磁界による磁化の方向が非常に安定し、且つ、非磁性層膜の膜厚を適当な範囲で選ぶことによって、非磁性層膜を介して対向する２つの固定磁性層膜の間で、反強磁性的に強く結合させることができ、磁化の方向が強く固定され、且つ、お互いの磁化の方向が逆の方向になって端面磁荷による漏れ磁界が抑えられ、端面における磁化の方向も非常に安定したものとなる。

【００３３】（実施の形態２）図４～図１１は本発明の実施の形態２を示す概略説明図であり、再生用磁気抵抗効果型薄膜磁気ヘッドの製造工程を説明するための工程概要説明図で、磁気記録媒体に対向するヘッド摺動面の近傍をヘッド摺動面に平行な面で断面にした概略断面図である。以下、図面を用いて再生用磁気抵抗効果型薄膜磁気ヘッドの製造方法を各工程順に説明する。

【００３４】図４に示すように、ＡｌＴｉＣ等を材料とした基板４０の上に成膜され、パーマロイ、Ｃｏ系アモルファス磁性膜或いはＦｅ系微粒子磁性膜等の軟磁性材料を素材とする下部シールド層４１の上にAl_2O_3、ＡｌＮ或いはSiO_2等の非磁性絶縁材料を用いて下部ギャップ絶縁層４２を成膜する。

【００３５】次に、第１の工程として、図５（ａ）に示すように、下部ギャップ絶縁層４２の上に、ＩｒＭｎ、αFe_2O_3、ＮｉＯ、ＦｅＭｎ系合金膜、ＮｉＭｎ系合金膜或いはＰｔＭｎ系合金膜等の材料を用いて反強磁性層５１を成膜し、更に、図５（ｂ）に示すように、その上に、ＮｉＦｅ系合金膜、Ｃｏ或いはＣｏＦｅ合金膜等を材料として固定磁性層５２を成膜する。次に、図５（ｃ）に示すように、固定磁性層５２の上に、Ｃｕ等を材料とする非磁性層５３を成膜する。更に、図５（ｄ）に示すように、非磁性層５３の上に、固定磁性層５２と同様の材料を用いてフリー磁性層５４を成膜し、反強磁性層５１、固定磁性層５２、非磁性層５３及びフリー磁性層５４が薄膜で順次積層成膜されたＧＭＲ素子５５を形成する。

【００３６】第２の工程として、図６（ａ）に示すように、ＧＭＲ素子５５の上に、ＧＭＲ素子５５を構成する反強磁性層５１とは異種の反強磁性材料（但し、場合によっては、αFe_2O_3、ＮｉＯ等の酸化金属材料は使わないほうが良い）を用いてバイアス反強磁性層膜６１を成膜した後、図６（ｂ）に示すように、ＧＭＲ素子５５及びバイアス反強磁性層膜６１の略中央部即ちヘッドトラック幅を形成する部分の近傍において、フォトレジストを塗布してバイアス反強磁性層膜６１の一部をドライエッチング等の方法により削り取り、削り取られて膜厚が小さくなっている第１の平面６２及び左右の削り取られていない膜厚の大きい第２の平面６３を有する段差のある反強磁性膜６４を形成する。

【００３７】第３の工程として、図７（ａ）に示すよう

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に、Ｃｕ、Ｃｒ或いはＴａ等の非磁性材料を用いて電極リード層膜７１を段差のあるバイアス反強磁性膜６４の上に成膜し、図７（ｂ）に示すように、バイアス反強磁性膜６４の膜厚の小さい部分の第１の平面６２の一部が露出するように、フォトレジストを塗布してドライエッチング等の方法により、少なくとも電極リード層膜７１の一部を削り取って、左右一対の電極リード層７２を形成する。　第４の工程として、図８に示すように、左右一対の電極リード層７２及びバイアス反強磁性膜６４の第１の平面６２の一部の露出した部分の上に、Ｔａ等の材料を用いてキャップ層８１を成膜する。

【００３８】次に、図示しないが、キャップ層８１、左右一対の電極リード層７２及びバイアス反強磁性膜６４を所定の形状にパターニングして削り取り、更に、それらの上に、下部ギャップ絶縁層４２と同様の絶縁材料を用いて上部ギャップ絶縁層を成膜し、更に、その上に、下部シールド層４１と同様の軟磁性材料を用いて上部シールド層を成膜形成して、再生用磁気抵抗効果型薄膜磁気ヘッドを作製する。

【００３９】また、前述の第１の工程として、図９（ａ）に示すように、下部ギャップ絶縁層４２の上に、反強磁性層５１を成膜し、更にその上に、ＮｉＦｅ系合金膜、Ｃｏ或いはＣｏＦｅ合金膜等を材料とした第１の固定磁性層膜９０１、Ｒｕ等の非磁性材料を用いた第１の非磁性層膜９０２、第１の固定磁性層膜９０１と同様の材料を用いた第２の固定磁性層膜９０３を順次積層成膜して、積層固定磁性層９１を形成し、その上に、Ｃｕ等を材料とする非磁性層５３及び第１の固定磁性層膜９０１等の材料と同様の材料を用いたフリー磁性層５４を順次成膜して、ＧＭＲ素子９２を形成しても良い。

【００４０】また、前述の第１の工程として、図９（ｂ）に示すように、下部ギャップ絶縁層４２の上に、反強磁性層５１、固定磁性層５２及び非磁性層５３を順次成膜し、更に、その上に第１のフリー磁性層膜９１１、第２のフリー磁性層膜９１２、……、第ｎのフリー磁性層膜９１３（ｎは２以上の正の整数）を順次積層成膜して、積層フリー磁性層９３を形成して、ＧＭＲ素子９４を形成しても良い。

【００４１】また、第１の工程にて積層成膜してＧＭＲ素子５５を形成する装置と第２の工程にてバイアス反強磁性層膜６１を成膜する装置が異なる場合には、第２の工程として、フリー磁性層５４の上面をＡｒ等によるプリスパッタ或いはＥＣＲ等の方法によってクリーニングし、フリー磁性層５４の上面の酸化膜、異物或いは汚れ等を取り除いた後、図６に示すように、バイアス反強磁性層膜６１を成膜して、ドライエッチング等の方法により、バイアス反強磁性層膜６１の一部を削り取り、膜厚差を有する段差のあるバイアス反強磁性膜６４を形成した方が好ましい。この時、フリー磁性層５４の上面をクリーニングすることによって、フリー磁性層５４とバイアス反強磁性膜６４との間には異物の介在がなく、非常に良好な密着性および磁気的な結合が安定して得られるため、バイアス反強磁性膜６４とフリー磁性層５４の結合磁界の強さが低下することなく、より安定した結合磁界を得ることができる。

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【００４２】また、前述の第３の工程において、図１０に示すように、バイアス反強磁性膜６４の第１の平面６２の上に、茸型レジスト１０１を形成して、バイアス反強磁性膜６４の上に左右一対の電極リード層１０２を成膜形成しても良い。

【００４３】また、第２の工程及び第３の工程において、第２の工程として、前述の第２の工程と同様にして図６（ａ）に示すように、フリー磁性層５４の上を覆うように、バイアス反強磁性層膜６１を成膜した後、第３の工程として、図１１（ａ）に示すように、更にその上を覆うように、電極リード層膜１１１を成膜し、図１１（ｂ）に示すように、フォトレジストを塗布して、電極リード層膜１１１及びバイアス反強磁性層膜６１の一部をドライエッチング等の方法により削り取って、中央部の膜厚が小さい第１の平面１１２を有し、左右に膜厚の大きい第２の平面１１３を有する段差のあるバイアス反強磁性膜１１４及びバイアス反強磁性膜１１４の第２の平面１１３の上に左右一対の電極リード層１１５を形成しても良い。尚、バイアス反強磁性層膜６１を成膜する前に、フリー磁性層５４の上面をクリーニングしておいても良いのは言うまでもない。

【００４４】以上のように本実施の形態２によれば、非常に強く磁化方向を固定したい部分（フリー磁性層のトラック幅部分以外の部分）に強いバイアス磁界をかけ、一方、バルクハウゼンノイズを抑えるためにバイアス磁界はかけなければならないが、強い磁界をかけると再生感度が低下するためあまり強い磁界をかけたくない部分（フリー磁性層のトラック幅部分）に最適なバイアス磁界をかけることが、それぞれの部分の反強磁性膜の膜厚によって容易に制御することが可能な磁気抵抗効果型薄膜磁気ヘッドを作製することができる。つまり、バイアス反強磁性膜とフリー磁性層との反強磁性結合した結合磁界は、バイアス反強磁性膜の膜厚によって変化する。即ち、バイアス反強磁性膜の膜厚が大きい程、結合磁界が大きくなり、ある程度以上の膜厚になればその結合磁界が飽和するという特性を利用して、膜厚差による段差を有するバイアス反強磁性膜をフリー磁性層の上に形成することによって、左右の膜厚の大きな部分に接しているフリー磁性層は非常に強い結合磁界で結合され、一方ヘッドトラック部近傍においてはフリー磁性層は膜厚の小さいバイアス反強磁性膜に接しており、比較的小さな結合磁界によって結合されるが、その磁化の方向は、膜厚の大きなバイアス反強磁性膜と強い結合磁界を有しているフリー磁性層の磁化の方向と同じ方向に向くことになり、非常に安定した磁化の方向が得られることになり、

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ノイズの少ない、再生感度の高い、高再生性能の磁気抵抗効果型薄膜ヘッドを作製することができる。また、バイアス反強磁性膜との結合磁界によってバイアス磁界をかけるため、ギャップレングスに関わらず同様の効果を有し、かつ、このバイアス磁界が固定磁性層に与える影響はなく、それによる固定磁性層の磁化の傾きも生じないため、出力波形の対称性の劣化が抑えられた磁気抵抗効果型薄膜ヘッドを作製することができる。

【００４５】尚、キャップ層を成膜することにより、バイアス反強磁性膜の露出した部分の酸化を防止し、耐食性を向上させることができる。

【００４６】また、固定磁性層或いはフリー磁性層の夫々に磁化の方向を付加する反強磁性層或いはバイアス反強磁性膜への夫々の熱処理（アニール処理）は、キャップ層が形成された後、且つキャップ層、電極リード層及びバイアス反強磁性膜が所定の形状にパターニングされて削り取られる前に、実施するのが良い。また、固定磁性層に磁化の方向を設定するための反強磁性層の熱処理条件とフリー磁性層に磁化の方向を付加するためのバイアス反強磁性膜の熱処理条件とは、磁界の強さ、熱処理温度及び熱処理時間の少なくとも１つの条件が異なるように、反強磁性層及びバイアス反強磁性膜の夫々の材料を選定しなければならない。

【００４７】尚、積層固定磁性層を形成することによって、所定の方向に磁化の方向が強く固定された固定磁性層の端面磁荷による漏れ磁界を、非磁性層膜を介して形成された固定磁性層膜で打ち消すことになり、ノイズを抑えることに効果がある。

【００４８】（実施の形態３）図１２～図１６は本発明の実施の形態３を示す概略説明図であり、再生用磁気抵抗効果型薄膜磁気ヘッドの製造工程を説明するための工程概要説明図で、磁気記録媒体に対向するヘッド摺動面の近傍をヘッド摺動面に平行な面で断面にした概略断面図である。以下、図面を用いて再生用磁気抵抗効果型薄膜磁気ヘッドの製造方法を各工程順に説明する。

【００４９】前述の実施の形態２と同様にして、第１の工程として、図５（ａ）に示すように、下部ギャップ絶縁層４２の上に、ＩｒＭｎ、αFe_2O_3、ＮｉＯ、ＦｅＭｎ系合金膜、ＮｉＭｎ系合金膜或いはＰｔＭｎ系合金膜等の材料を用いて反強磁性層５１を成膜し、更に、図５（ｂ）に示すように、その上に、ＮｉＦｅ系合金膜、Ｃｏ或いはＣｏＦｅ合金膜等を材料として固定磁性層５２を成膜する。次に、図５（ｃ）に示すように、固定磁性層５２の上に、Ｃｕ等を材料とする非磁性層５３を成膜する。更に、図５（ｄ）に示すように、非磁性層５３の上に、固定磁性層５２と同様の材料を用いてフリー磁性層５４を成膜し、反強磁性層５１、固定磁性層５２、非磁性層５３及びフリー磁性層５４が薄膜で順次積層成膜されたＧＭＲ素子５５を形成する。

【００５０】第２の工程として、図１２（ａ）に示すように、ＧＭＲ素子５５の上に、ＧＭＲ素子５５を構成する反強磁性層５１とは異種の反強磁性材料（但し、場合によっては、αFe_2O_3、ＮｉＯ等の酸化金属材料は使わないほうが良い）を用いて第１のバイアス反強磁性膜１２１を成膜する。次に、図１２（ｂ）に示すように、茸型レジスト１２２を形成して、第１のバイアス反強磁性膜１２１の上に、第１のバイアス反強磁性膜１２１と同様の反強磁性材料を用いて左右一対の第２のバイアス反強磁性膜１２３を成膜形成し、第１のバイアス反強磁性膜１２１の上面である第１の平面１２４とその第１のバイアス反強磁性膜１２１の上に形成された第２のバイアス反強磁性膜１２３の上面である第２の平面１２５を有し、第１の平面部ではその膜厚は第１のバイアス反強磁性膜１２１の膜厚そのものであり、第２の平面部では第１のバイアス反強磁性膜１２１と第２のバイアス反強磁性膜１２３の夫々の膜厚の和であり、膜厚差による段差を有するバイアス反強磁性膜１２６を形成することができる。ここで、第１のバイアス反強磁性膜１２１及び第２のバイアス反強磁性膜１２３の材料は、フリー磁性層５４に磁化の方向を付加するための熱処理条件（加える磁界の強さ、熱処理温度及び熱処理時間）が固定磁性層５２に磁化の方向を付加するための反強磁性層５１の熱処理条件と少なくとも１つの条件において異なるように選ばれなければならない。また、第１のバイアス反強磁性膜１２１と第２のバイアス反強磁性膜１２３の材料は、第２の反強磁性膜１２３を形成することによりフリー磁性層との結合磁界が大きくなるのであれば異種の反強磁性材料であっても良く、この時、第１のバイアス反強磁性膜１２１と第２のバイアス反強磁性膜１２３に適した条件で熱処理を実施することが必要になる。

【００５１】第３の工程として、図１３に示すように、茸型レジスト１２２を利用して、左右一対の第２のバイアス反強磁性膜１２３の上に、Ｃｕ、Ｃｒ或いはＴａ等の非磁性材料を用いて左右一対の電極リード層１３１を成膜形成する。

【００５２】第４の工程として、図１４に示すように、左右一対の電極リード層１３１及び第１のバイアス反強磁性膜１２１の露出した部分の上に、Ｔａ等の材料を用いてキャップ層１４１を成膜する。

【００５３】次に、図示しないが、キャップ層１４１、左右一対の電極リード層１３１及びバイアス反強磁性膜１２６を所定の形状にパターニングして削り取り、更に、それらの上に、下部ギャップ絶縁層４２と同様の絶縁材料を用いて上部ギャップ絶縁層を成膜し、更に、その上に、下部シールド層４１と同様の軟磁性材料を用いて上部シールド層を成膜形成して、再生用磁気抵抗効果型薄膜磁気ヘッドを作製する。

【００５４】尚、前述の実施の形態２の第１の工程の他の例と同様にして、積層固定磁性層或いは積層フリー磁性層を形成して、ＧＭＲ素子を形成することができるの

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は言うまでもない。

【００５５】また、第２の工程の他の一例として、図１２（ｂ）に示すように、茸型レジスト１２２を形成して、第１のバイアス反強磁性膜１２１の上面をＡｒ等によるプリスパッタ或いはＥＣＲ等の方法によってクリーニングし、第１のバイアス反強磁性膜１２１の表面の酸化膜、レジストの残滓、異物或いは汚れ等を取り除いた後、第１のバイアス反強磁性膜１２１の上に、第１のバイアス反強磁性膜１２１と同様の反強磁性材料を用いて左右一対の第２のバイアス反強磁性膜１２３を成膜形成することにより、第１のバイアス反強磁性膜１２１と第２のバイアス反強磁性膜１２３との間には異物の介在がなく、非常に良好な密着性および磁気的な結合が安定して得られるため、バイアス反強磁性膜とフリー磁性層の結合磁界の強さが低下することなく、より安定した結合磁界を得ることができる。。

【００５６】また、第２の工程の他の例として、前述の実施の形態２の第２の工程の他の例と同じように、第２の工程における第１のバイアス反強磁性層膜６１を成膜する装置が第１の工程におけるＧＭＲ素子５５を形成する装置と異なるときは、フリー磁性層５４の上面をＡｒ等によるプリスパッタ或いはＥＣＲ等の方法によってクリーニングし、フリー磁性層５４の表面の酸化膜、レジストの残滓、異物或いは汚れ等を取り除いた後、図１２に示す第２の工程と同じようにして、クリーニングされたフリー磁性層５４の上を覆うように第１のバイアス反強磁性膜１２１を成膜し、その上に茸型レジスト１２２を形成して、左右一対の第２のバイアス反強磁性膜１２３を成膜形成した方が良い。前述の実施の形態２と同様に、バイアス反強磁性膜とフリー磁性層の結合磁界の強さが低下することなく、より安定した結合磁界を得ることができる。

【００５７】また、第３の工程の他の一例として、第２の工程で形成した茸型レジストを削除した後、図１５（ａ）に示すように、左右一対の第２のバイアス反強磁性膜１２３及び第１のバイアス反強磁性膜１２１の露出した部分の上を覆うように、電極リード層膜１５１を成膜し、図１５（ｂ）に示すように、第１のバイアス反強磁性膜１２１の第１の平面１２４の一部が露出するように、フォトレジストを塗布してドライエッチング等の方法により、少なくとも電極リード層膜１５１の一部を削除して、左右一対の電極リード層１５２を形成しても良い。

【００５８】また、第３の工程の他の例として、第２の工程で形成した茸型レジストを削除した後、図１６に示すように、第１のバイアス反強磁性膜１２１の上に、別の茸型レジスト１６１を形成して、左右一対の電極リード層１６２を成膜形成しても良い。

【００５９】以上のように本実施の形態３によれば、前述の実施の形態２と同様に、膜厚の大きなバイアス反強

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磁性膜に接しているフリー磁性層は非常に強い結合磁界によりバイアス反強磁性膜と反強磁性結合し、膜厚の小さいバイアス反強磁性膜に接しているフリー磁性層の磁化の方向は、膜厚の大きなバイアス反強磁性膜に接しているフリー磁性層と同じ磁化の方向に安定して向くことになり、非常に安定した磁化の方向が得られ、また、上面がクリーニングされた第１の反強磁性膜の上に、第２の反強磁性膜を成膜形成することによって、第１の反強磁性膜と第２の反強磁性膜の間で、非常に良好な密着性および磁気的な結合が安定して得られ、膜厚の大きな反強磁性膜と強い反強磁性結合による結合磁界を有しているフリー磁性層の磁化の方向が非常に安定したものとなり、ノイズの少ない、再生感度の高い、高再生性能の磁気抵抗効果型薄膜ヘッドを作製することができる。また、バイアス反強磁性膜との結合磁界によってバイアス磁界をかけるため、ギャップレングスに関わらず同様の効果を有し、かつ、このバイアス磁界が固定磁性層に与える影響はなく、それによる固定磁性層の磁化の傾きも生じないため、出力波形の対称性の劣化が抑えられた磁気抵抗効果型薄膜ヘッドを作製することができる。

【００６０】尚、前述の実施の形態２～実施の形態３において、固定磁性層及びフリー磁性層に夫々所定の方向に磁化の方向を付加する熱処理は、第４の工程として、キャップ層が成膜された後、且つ、キャップ層、電極リード層、バイアス反強磁性膜及びＧＭＲ素子が所定の形状にパターニングされて削り取られる前に、実施するのが好ましい。ここで、固定磁性層に磁化の方向を付加する反強磁性層への熱処理条件（磁界の強さ、処理温度及び処理時間）と、フリー磁性層に磁化の方向を付加するバイアス反強磁性膜への熱処理条件は少なくとも１つの条件項目が異なるように、夫々固定磁性層に接する反強磁性層及びフリー磁性層に接するバイアス反強磁性膜の材料を選ばねばならないのは言うまでもない。

【００６１】（実施の形態４）図１７～図２０は、本発明の実施の形態４を示す概略説明図であり、再生用磁気抵抗効果型薄膜磁気ヘッドの製造工程を説明するための工程概要説明図で、磁気記録媒体に対向するヘッド摺動面の近傍をヘッド摺動面に平行な面で断面にした概略断面図である。以下、図面を用いて再生用磁気抵抗効果型薄膜磁気ヘッドの製造方法を各工程順に説明する。

【００６２】前述の実施の形態２の第１の工程と同じようにして、図５に示されるように、反強磁性層５１、固定磁性層５２、非磁性層５３及びフリー磁性層５４が順次積層成膜されたＧＭＲ素子５５を形成する。

【００６３】第２の工程として、図１７（ａ）に示すように、ＧＭＲ素子５５の最上部にあるフリー磁性層５４の上を覆うように、第１のバイアス反強磁性膜１７１を成膜し、更にその上に、キャップ層１７２を成膜する。次に、図１７（ｂ）に示すように、キャップ層１７２の上に茸型レジスト１７３を形成して、第１のバイアス反

強磁性膜１７１の表面が左右に露出するように、キャップ層１７２を削り取り、図１７（ｃ）に示すように、その上に、左右一対の第２のバイアス反強磁性膜１７４を成膜形成して、膜厚の異なる段差を有する反強磁性膜１７５を形成する。

【００６４】第３の工程として、図１８に示すように、茸型レジスト１７３を利用して、左右一対の第２のバイアス反強磁性膜１７４の上に、Ｃｕ、Ｃｒ或いはＴａ等の非磁性材料を用いて左右一対の電極リード層１８１を成膜形成する。

【００６５】それ以降の工程は、前述の実施の形態２と同じである。

【００６６】尚、前述の実施の形態２の第１の工程の他の例と同様にして、積層固定磁性層或いは積層フリー磁性層を形成しても良いことは言うまでもない。

【００６７】また、第２の工程の他の一例として、前述の実施の形態３の第２の工程の他の一例と同じように、図１７（ｂ）に示すように、キャップ層１７２の上に茸型レジスト１７３を形成して、第１のバイアス反強磁性膜１７１の表面が左右に露出するように、キャップ層１７２を削り取り、別の装置を用いて第２のバイアス反狭磁性膜を成膜形成する場合には、露出した第１のバイアス反強磁性膜１７１の上面をＡｒ等によるプリスパッタ或いはＥＣＲ等の方法によってクリーニングし、第１のバイアス反強磁性膜１７１の表面の酸化膜、レジストの残滓、異物或いは汚れ等を取り除いた後、第１のバイアス反強磁性膜１７１の上に、左右一対の第２のバイアス反強磁性膜１７４を成膜形成して、膜厚の異なる段差を有する反強磁性膜１７５を形成した方が好ましい。上面がクリーニングされた第１の反強磁性膜の上に、第２の反強磁性膜を成膜形成することによって、第１の反強磁性膜と第２の反強磁性膜の間で、非常に良好な密着性および磁気的な結合が安定して得られ、膜厚の大きな反強磁性膜と強い反強磁性結合による結合磁界を有しているフリー磁性層の磁化の方向が非常に安定したものとなる。

【００６８】また、第２の工程における第１のバイアス反強磁性層膜１７１を成膜する装置が第１の工程におけるＧＭＲ素子５５を形成する装置と異なる場合は、第２の工程の他の一例として、前述の実施の形態３の第２の工程の他の例と同じように、フリー磁性層５４の上面をＡｒ等によるプリスパッタ或いはＥＣＲ等の方法によってクリーニングし、フリー磁性層５４の表面の酸化膜、レジストの残滓、異物或いは汚れ等を取り除いた後、図１７に示す第２の工程と同じようにして、クリーニングされたフリー磁性層５４の上を覆うように第１のバイアス反強磁性膜１７１を成膜し、更にその上に、キャップ層１７２を成膜して、その上に茸型レジスト１７３を形成して、左右一対の第２のバイアス反強磁性膜１７４を成膜形成した方が良い。この時、フリー磁性層５４の上

面をクリーニングすることによって、フリー磁性層５４と第１のバイアス反強磁性膜１７１との間には異物の介在がなく、非常に良好な密着性および磁気的な結合が安定して得られるため、バイアス反強磁性膜とフリー磁性層の結合磁界の強さが低下することなく、より安定した結合磁界を得ることができる。

【００６９】また、第３の工程の他の一例として、第２の工程で形成された茸型レジストを削除した後、図１９に示すように、第２のバイアス反強磁性膜１７４及び露出しているキャップ層１７２の上を覆うように、電極リード層膜１９１を成膜し、その後、キャップ層１７２の一部が露出するように、フォトレジストを塗布してドライエッチング等の方法により電極リード層膜１９１を削り取り、左右一対の電極リード層１９２を形成しても良い。また、電極リード層を削り取った後、バイアス反強磁性膜１７１を削らないようにキャップ層１７２の材料を選択することも可能である。

【００７０】また、第３の工程の他の例として、第２の工程で形成された茸型レジストを削除した後、図２０に示すように、キャップ層１７２の上に、別の茸型レジスト２０１を形成して、左右一対の電極リード層２０２を形成しても良い。

【００７１】尚、固定磁性層及びフリー磁性層に夫々所定の方向に磁化の方向を付加するための反強磁性層及びバイアス反強磁性膜への夫々の熱処理は、キャップ層が成膜された後、且つ、バイアス反強磁性膜及びＧＭＲ素子が所定の形状にパターニングされて削り取られる前に、実施するのが好ましい。ここで、固定磁性層に磁化の方向を付加するための反強磁性層への熱処理条件（磁界、処理温度及び処理時間）と、フリー磁性層に磁化の方向を付加するためのバイアス反強磁性膜への熱処理条件は少なくとも１つの条件項目が異なるように、夫々固定磁性層に接する反強磁性層及びフリー磁性層に接するバイアス反強磁性膜の材料を選ばねばならないのは言うまでもない。

【００７２】以上のように本実施の形態４によれば、前述の前述の実施の形態２及び実施の形態３と同様に、膜厚の大きなバイアス反強磁性膜に接しているフリー磁性層の非常に強い反強磁性結合により、膜厚の小さいバイアス反強磁性膜に接しているフリー磁性層の磁化の方向は、膜厚の大きなバイアス反強磁性膜に接しているフリー磁性層と同じ磁化の方向に向き易くなることになり、非常に安定した磁化の方向が得られ、また、上面がクリーニングされた第１の反強磁性膜の上に、第２の反強磁性膜を成膜形成することによって、第１の反強磁性膜と第２の反強磁性膜の間で、非常に良好な密着性および磁気的な結合が安定して得られ、膜厚の大きな反強磁性膜と強い反強磁性結合による結合磁界を有しているフリー磁性層の磁化の方向が非常に安定したものとなり、また、本製造方法によって第１の反強磁性膜の上にキャッ

プ層を設けることによって、バイアス反強磁性膜が露出する時間を大幅に削減できるため、バイアス反強磁性膜の特性劣化を抑えることができ、バルクハウゼンノイズの少ない、再生感度の高い、優れた再生性能の磁気抵抗効果型薄膜ヘッドを作製することができる。

【００７３】

【発明の効果】以上のように本発明は、反強磁性膜に接している軟磁性膜の結合磁界は、反強磁性膜の膜厚が大きければ大きくなり、ある範囲以上になれば略飽和するという特性を利用して、ＧＭＲ素子のフリー磁性層の上に、ヘッドトラックを構成する部分の近傍では膜厚が小さく、ヘッドトラック近傍以外は膜厚が大きくなるように段差を有するバイアス反強磁性膜を設けることによって、膜厚の大きな部分のバイアス反強磁性膜に接しているフリー磁性層の部分は、バイアス反強磁性膜と反強磁性結合して非常に強い結合磁界で結合され、その磁化の方向は非常に安定したものとなり、そのため膜厚の小さい部分のバイアス反強磁性膜に接している部分のフリー磁性層は小さい結合磁界でも、安定して膜厚の大きいバイアス反強磁性膜に接しているフリー磁性層の部分の磁化方向と同じ方向に向き易く安定した磁化の方向が得られ、また、膜厚の小さい部分の反強磁性膜に接しているフリー磁性層の部分の反強磁性結合磁界が小さいため、磁気記録媒体からの磁界によって磁化の方向が変化し易くなり、バルクハウゼンノイズが小さく、再生感度が高い等の再生性能を向上できるという効果が、再生ギャップレングスに関わらず得らる。また、そのような優れた再生性能を有する磁気抵抗効果型薄膜磁気ヘッドが作製できるという効果を有している。

【図面の簡単な説明】

【図１】本発明の実施の形態１を示す薄膜磁気ヘッドの正面概略模式図

【図２】本発明の実施の形態１の他の例を示す薄膜磁気ヘッドの一部の正面概略模式図

【図３】本発明の実施の形態１を説明するためのフリー磁性層に付加された層間結合磁界の強さと再生出力の関係を示すグラフ

【図４】本発明の実施の形態２を説明する薄膜磁気ヘッドの製造工程の一部の工程を示す概略説明図

【図５】本発明の実施の形態２における第１の工程を示す概略説明図

【図６】本発明の実施の形態２における第２の工程を示す概略説明図

【図７】本発明の実施の形態２における第３の工程を示す概略説明図

【図８】本発明の実施の形態２における第４の工程を示す概略説明図

【図９】本発明の実施の形態２における第１の工程の他の例を示す概略説明図

【図１０】本発明の実施の形態２における第３の工程の他の一例を示す概略説明図

【図１１】本発明の実施の形態２における第３の工程の他の例を示す概略説明図

【図１２】本発明の実施の形態３における第２の工程を示す概略説明図

【図１３】本発明の実施の形態３における第３の工程を示す概略説明図

【図１４】本発明の実施の形態３における第４の工程を示す概略説明図

【図１５】本発明の実施の形態３における第３の工程の他の例を示す概略説明図

【図１６】本発明の実施の形態３における第３の工程の他の例を示す概略説明図

【図１７】本発明の実施の形態４における第２の工程を示す概略説明図

【図１８】本発明の実施の形態４における第３の工程を示す概略説明図

【図１９】本発明の実施の形態４における第３の工程の他の一例を示す概略説明図

【図２０】本発明の実施の形態４における第３の工程の他の例を示す概略説明図

【図２１】従来の薄膜磁気ヘッドを示す斜視概略図

【図２２】従来の薄膜磁気ヘッドを示す正面概略模式図

【符号の説明】

１、５１、２２４　反強磁性層

２、５２、２２５　固定磁性層

３、５３、２２６　非磁性層

４、５４、２２７　フリー磁性層

５、５５、９２、９４、２１３　磁気抵抗効果素子（ＧＭＲ素子）

６、６２、１１２、１２４　第１の平面

７、６３、１１３、１２５　第２の平面

８、６４、１１４、１２６、１７５　バイアス反強磁性膜

９、７２、１０２、１１５、１３１、１５２、１６２、１８１、１９２、２０２、２１５　電極リード層

１０、８１、１４１、１７２、２２８　キャップ層

４０　基板

４１、２１１　下部シールド層

４２、２１２　下部ギャップ絶縁層

６１　バイアス反強磁性層膜

７１、１１１、１５１、１９１　電極リード層膜

９１　積層固定磁性層

９３　積層フリー磁性層

１０１、１２２、１６１、１６３、２０１　茸型レジスト

１２１、１７１　第１のバイアス反強磁性膜

１２３、１７４　第２のバイアス反強磁性膜

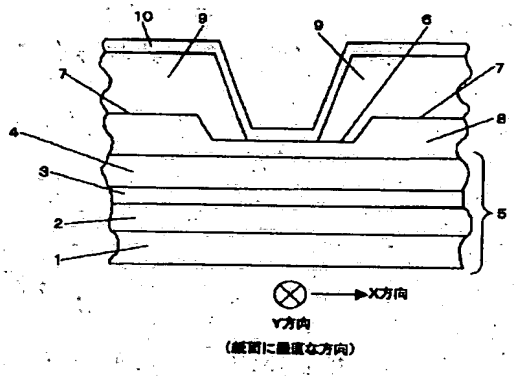
２１４　縦バイアス層

２１６　上部ギャップ絶縁層

２１７　上部シールド層
２１８　再生用磁気抵抗効果型薄膜磁気ヘッド
２２０　記録用誘導型薄膜磁気ヘッド
２２１　記録ギャップ層
２２２　上部磁極
２２３　巻線コイル
２２９　再生ヘッドギャップレングス

９０１　第１の固定磁性層膜
９０２　第１の非磁性層膜
９０３　第２の固定磁性層膜
９１１　第１のフリー磁性層膜
９１２　第２のフリー磁性層膜
９１３　第ｎのフリー磁性層膜

【図１】



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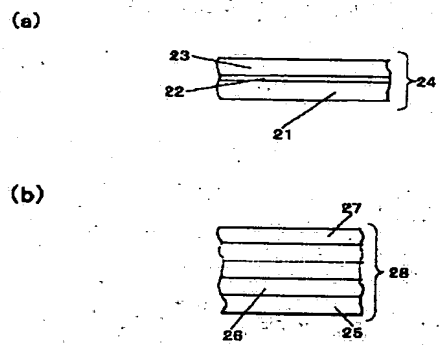

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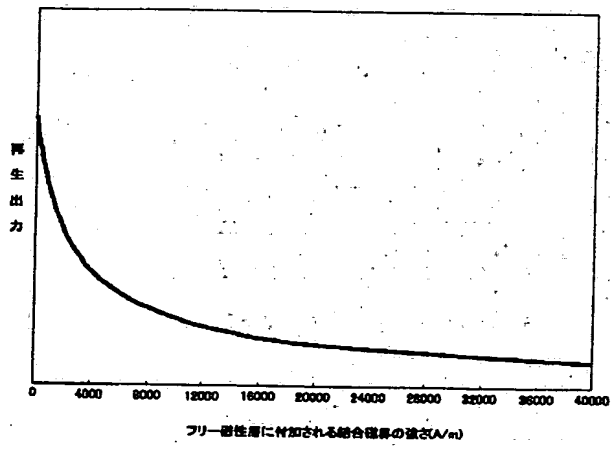

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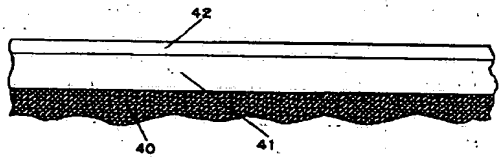

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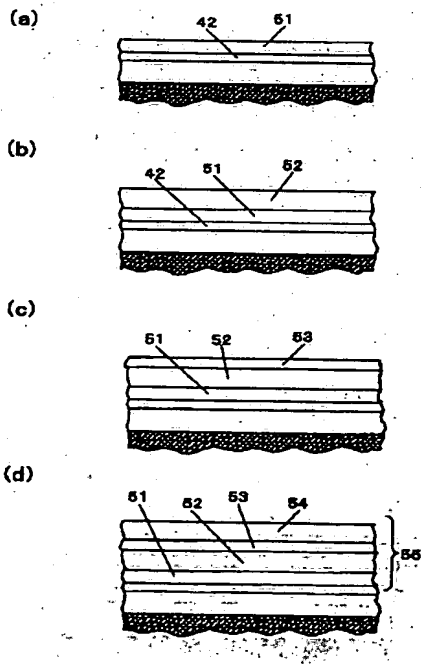

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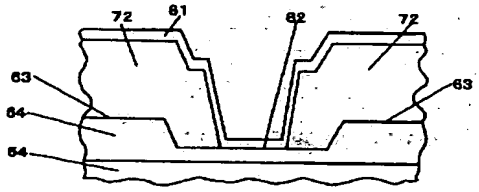

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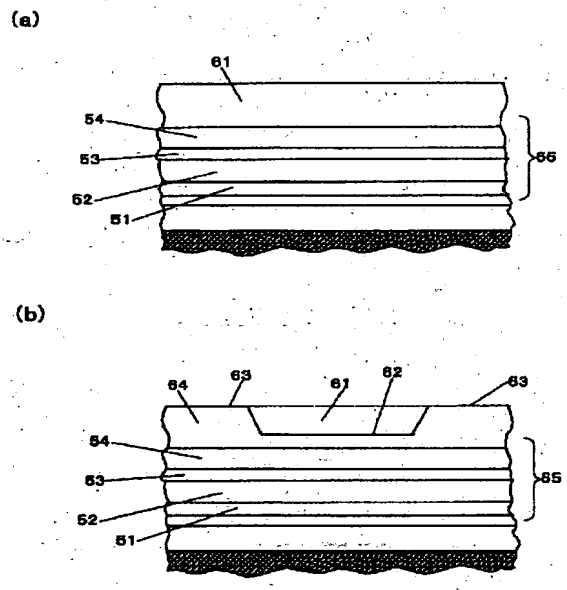

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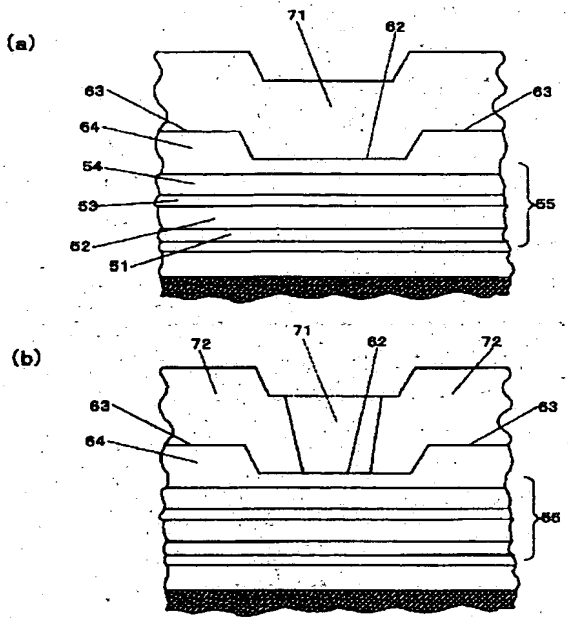

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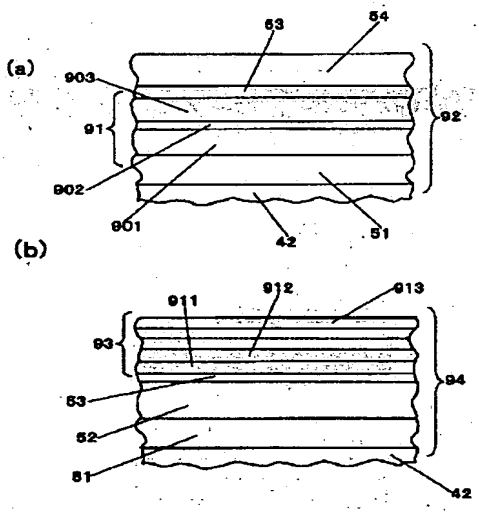

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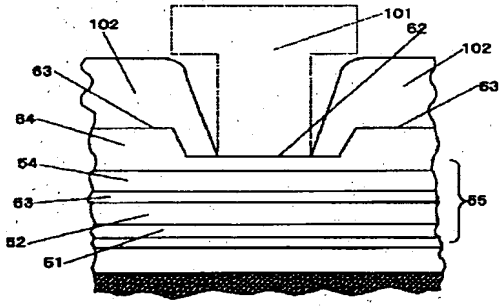

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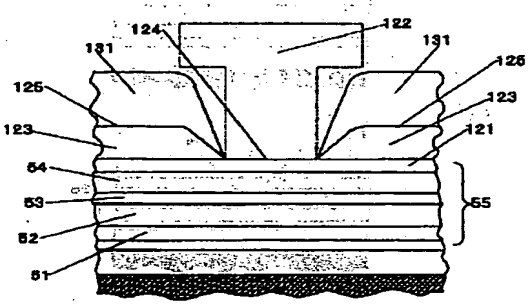

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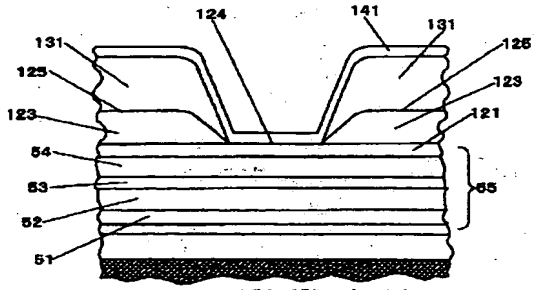

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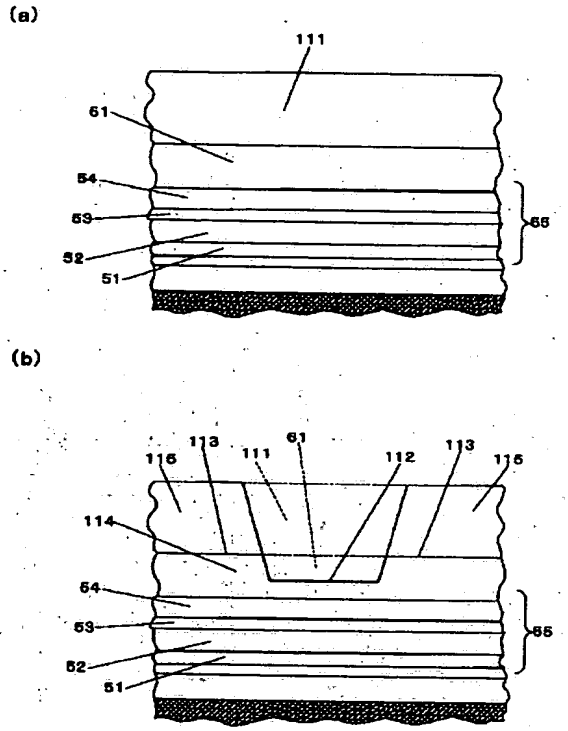

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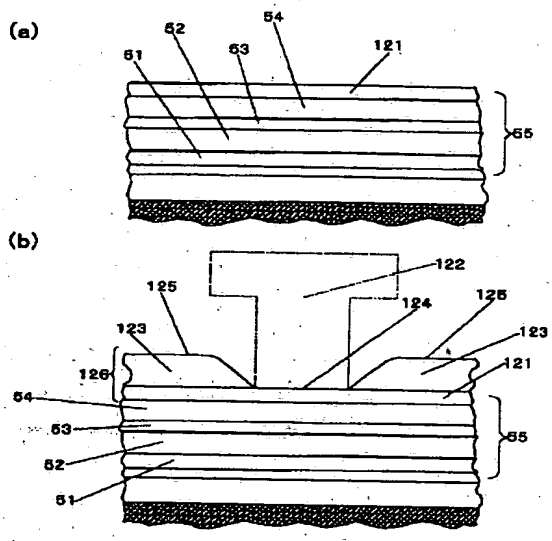

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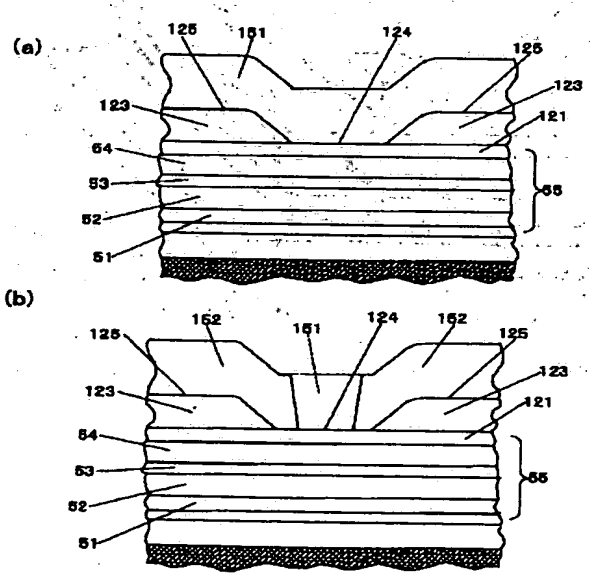

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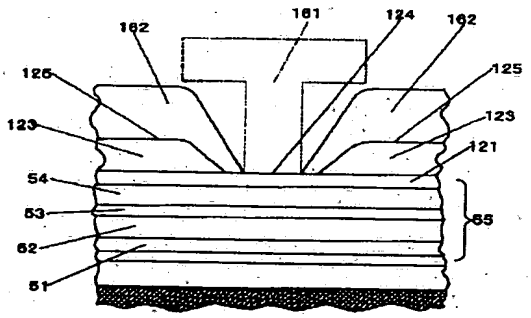

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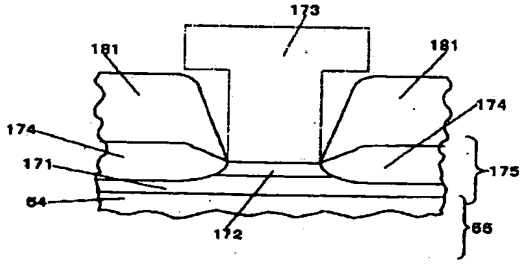

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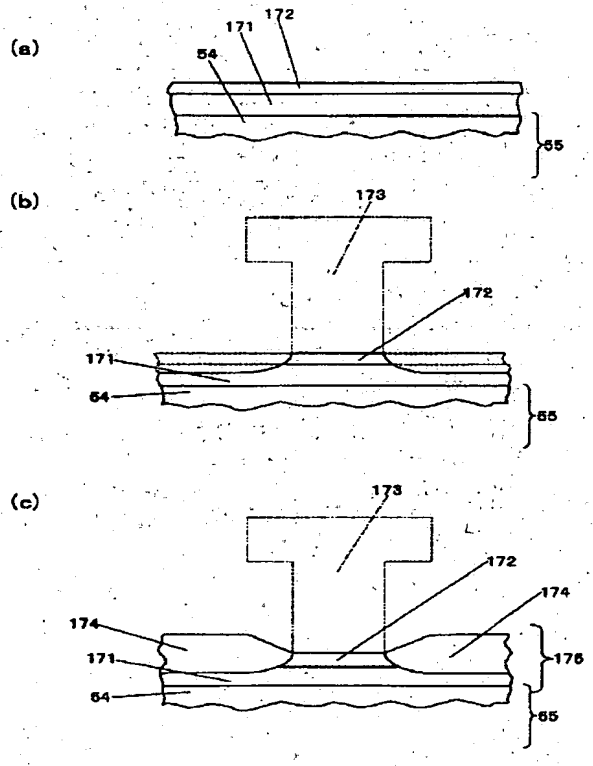

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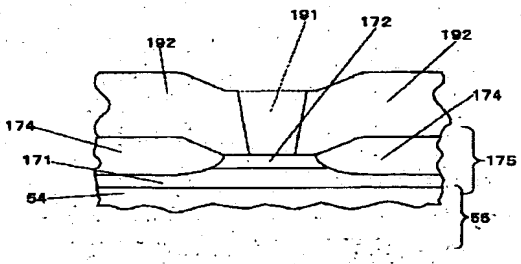

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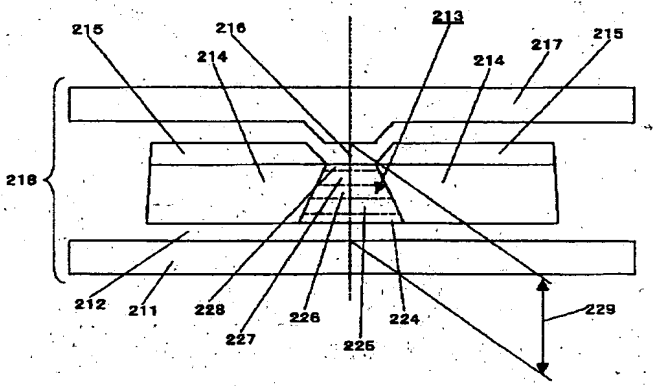

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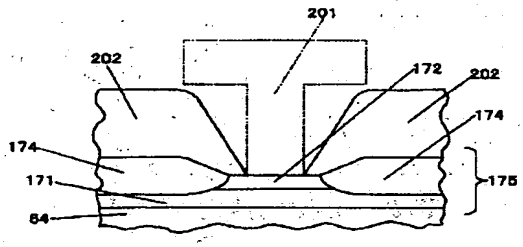

【図２１】